Fixed Link between Labrador and Newfoundland Pre-feasibility Study Final Report

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APPENDIX G	Economic Analysis Workbooks

This report has been prepared by Hatch Mott MacDonald (HMM), who have worked independently under contract to the Leslie Harris Centre of Regional Policy and Development, "the Harris Centre", formerly the "Public Policy Research Centre". The material within this report is intended for use by the Harris Centre, the Government of Newfoundland and Labrador and the Government of Canada. The distribution of the report will be as determined by the Government of Newfoundland and Labrador and the Government of Canada. It reflects the information available and the judgement of HMM and its subconsultants. Acceptance of this report by the Harris Centre or by the Province or the Federal Government is for contractual purposes only, and should not be construed as acceptance of the opinions and conclusions contained therein. Any use, which a third part makes of this report, or any reliance on decisions to be based on it, is the responsibility of such party.

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EXECUTIVE SUMMARY

Background and Purpose

The concept of providing a fixed transportation link between the Island of Newfoundland and Labrador across the Strait of Belle Isle has been the subject of discussion for many years. In early 2004, the Public Policy Research Centre of Memorial University, acting on behalf of the Government of Newfoundland and Labrador requested a proposal from independent consultants to conduct a study of fixed link concepts at a pre-feasibility level. In April, 2004, the Policy Centre awarded a contract for the study to Hatch Mott MacDonald.

In keeping with the Terms of Reference, the study was undertaken in four distinct phases as follows:

- Phase 1 – Background and Research.
- Phase 2 – Engineering and Technical Feasibility Options Analysis.
- Phase 3 - Economic and Business Case Analysis.
- Phase 4 - Financing Considerations.

Overview of Previous Work

The most relevant work in the study area is that carried out over a 10-year period in the 1970's and early 1980's by the Lower Churchill Development Corporation (LCDC). This comprehensive program of site investigations and engineering studies related to the crossing of the Strait, for the purposes of electricity transmission, by means of a tunnel constructed in the deep Precambrian granite underneath the Strait. The tunnel was to be created using drill-and-blast methods and, by being in this zone, potential problems with water ingress and fragmented rock in the upper sedimentary layers would be avoided. By late 1979, however, as more sophisticated studies of the risk associated with iceberg scour problems were conducted, it was concluded that a trenched submarine cable crossing route could be selected. Information obtained from approximately 40 reports on various aspects of the crossing, made available to the study by Newfoundland and Labrador Hydro, formed the basis of the study background.

Other Relevant Fixed Links & Tunnels Worldwide

In order to obtain an appreciation of the parameters relating to major fixed links and to make a comparison with the subject fixed link, a review was conducted of eight tunnels, causeways and bridges. The review showed that the costs varied from $10 million per kilometre for the Laerdal Tunnel in Norway to $700 million per kilometre for the Channel Tunnel, illustrating that the location and characteristics of the project can have a dramatic effect on the cost of the facility.

The Environment and Geology of the Study Area

The Strait of Belle Isle, generally speaking, is an inhospitable area in which to carry out major surface-related construction because of its unpredictable weather, high currents, sea ice and icebergs. The depth of the Strait varies significantly over its length with the area of the shortest crossing containing water as deep as 100m.

The geology of the Strait in the vicinity of the shortest crossing consists of a sedimentary layer of sandstones and limestone that is overlain by soil of various depth and constituency. Underlying this layer of rock is an approximately 500 metre thick layer of Precambrian granitic gneiss that varies from 130 metres below the ground surface on the Labrador side to 475 metres below on the Newfoundland side. An item of some concern is the potential for water ingress through the less competent sedimentary layer.

Assessment of Alternative Fixed Link Concepts

Three basic fixed link concepts were studied: bridge, causeway with bridges, and tunnel. In the case of a tunnel, the options were further divided into bored, drill and blast, and immersed tube (ITT). Both road and rail modes were considered for the tunnel option. Initial capacity assessment indicated that the projected traffic could be accommodated with excess capacity by a two lane above ground facility or with appropriate capacity by a single lane tunnel operated periodically in each direction by road vehicles or by roll-on/roll-off shuttle trains

For each of these concepts, the route across the Strait was taken as that between Pointe Amour and Yankee Point, which is the shortest distance, at 18 kilometres.

Bridge

A bridge crossing of the Strait would present very large risks, including design, construction and operation issues relating to the iceberg zone, and deep water depths and difficult weather conditions. Because of the water depths in the Strait and the need to minimize the exposure of structures to iceberg loadings, it is clear that the largest possible spans and, hence, suspension bridges of 2 kilometre spans would be used. A clearance of at least 50 metres is needed between the bridge deck and sea level to accommodate vessels and icebergs. All of the bridge piers would have to be protected by berms in order to withstand impact forces from icebergs.

Causeway

A causeway across the Strait of Belle Isle would be an ambitious undertaking, although with possibly lower risk than for a full bridge concept. While a causeway would still need one or more bridges, it could cope more easily with ice and icebergs and the bridge piers could be integrated into the causeway for protection. Foundations and anchoring for the bridges would still be very challenging; however, the number of foundations would be less. An obvious major environmental risk is the possible effects that such a structure could have on marine life and on the current regime in the area. For the purposes of this study, it has been assumed that two openings, spanned by bridges, would be needed in the causeway and that these would be located at the position of the shipping lanes.

Tunnels

Most of the risk factors associated with a surface crossing of the Strait of Belle Isle are eliminated with a tunnel that is constructed below the seabed. For an ITT, the risk of iceberg impact still exists. An immersed tube tunnel would consist of a series of connected and sealed pre-fabricated tunnel units within a pre-dredged trench in the seabed. The tunnel units are floated to their required location and sunk to their final position. The tunnel elements would have to be protected either by being buried below the depth of iceberg scour or by having sufficient protection to absorb the energy of an iceberg.

One of the primary risks associated with drill-and-blast or bored tunnels relates to the potential for water ingress through faulted and fragmented rock. For the electrical transmission cable tunnel, planned in the 1970's, the concern relating to water ingress caused the selection of a deep alignment at 400-500 metres below sea level. This placed the tunnel in the Precambrian gneiss layers that were considered to be significantly less permeable than the sedimentary rock layers above. For a transportation tunnel, such a deep alignment is not an option since with typical transportation downgrades and upgrades, the length of tunnel dictated would be prohibitively expensive. Fortunately, developments in tunnel excavation techniques in recent years have made possible a shallower tunnel within the sedimentary layer.

Two excavation techniques are available; these are drill-and-blast excavation and bored tunnels utilizing a tunnel boring machine. For the drill-and-blast excavation, water ingress must be reduced by grouting ahead of the tunnel face to seal water paths. This is not absolutely reliable in preventing water ingress and therefore a separation from the seabed of approximately 60 metres was selected for this analysis. For the bored tunnel option, the tunnel lining is installed immediately as the tunnel is progressed, water ingress is prevented and a higher alignment is possible. A bored tunnel would be constructed by a pressurized face tunnel boring machine (TBM). This type of TBM is designed to apply pressure to the excavation face to support the ground and to counteract water pressure in fractures and fissures. For this study, the highest practicable alignment, with about 10 metres of rock cover was selected. Because a drill & blast tunnel would be located further down in the sedimentary layer, the road and rail options are 0.3 kilometre and 4.4 kilometres longer than the respective tunnels constructed using TBM.

Comparison Summary of Alternatives

Table 1 provides a comparative summary of all alternatives based on the road and rail options.

Table 1 - Summary Comparison of Options for the Fixed Link

Option	Construction Cost ($millions 2004 dollars)	Annual Operating Cost ($millions 2004 dollars)	Risk Level	Preliminary Schedule (years)
Road Options				
TBM Bored Tunnel	1,559	6.8	Moderate	12.2
Drill & Blast Tunnel	1,800	6.8	High	17.8
Immersed Tube Tunnel	4,810	6.8	High	14.7
Bridge	4,227	16.9	Extreme	15
Bridge / Causeway	10,123	4.3	High	18
Rail Options				
TBM Bored Tunnel	1,184	7.64	Moderate	10.7
Drill & Blast Tunnel	2,272	7.64	High	23.8
Immersed Tube Tunnel	3,814	7.64	High	15

One of the primary risks associated with drill-and-blast or bored tunnels relates to the potential for water ingress through faulted and fragmented rock. For the electrical transmission cable tunnel, planned in the 1970's, the concern relating to water ingress caused the selection of a deep alignment at 400-500 metres below sea level. This placed the tunnel in the Precambrian gneiss layers that were considered to be significantly less permeable than the sedimentary rock layers above. For a transportation tunnel, such a deep alignment is not an option since with typical transportation downgrades and upgrades, the length of tunnel dictated would be prohibitively expensive. Fortunately, developments in tunnel excavation techniques in recent years have made possible a shallower tunnel within the sedimentary layer.

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The table illustrates that a TBM bored tunnel would have the lowest cost and risk, and a rail option would be less costly than a road option. A shuttle train in a TBM bored tunnel is therefore the preferred concept. The total development cost, including interest during construction and escalation, for the preferred concept would be approximately $1.7 billion.

Implementation Schedule

In all cases, three years were allowed for additional studies, field investigations, environmental assessment and other planning activities, and two years were allowed for detailed design for a total of 5 years prior to start of construction.

Using two TBM's, one from each side of the Strait and a seven-day work week provides the shortest construction and commissioning period for the rail tunnel of 5.7 years for a total project implementation time of 10.7 years.

Regulatory and Environmental Issues

Of the concepts addressed, a tunnel will have the least effect on the environment, in particular the physical environment of the Strait. The potential large scale oceanographic and climatic effects that might be wrought by a surface crossing such as a causeway and bridge would be avoided. In the Strait itself, there would be very little or no effect from the actual tunnelling process or from the traffic once the tunnel is completed.

The principal concern with respect to the tunnel itself is likely to be the disposal of the excavated material. Overall, while the project would be a major undertaking over a long construction period, its nature is such that there would not likely be major environmental concerns that are outside the realm of a typical heavy construction and earth moving project.

A complete assessment of the environmental implications and requirements would be required to be undertaken at a later stage of the project.

Economic and Business Case Analysis

Three scenarios for addressing the crossing have been analysed. These are as follows:

a) The Base Case – a bored, 2 TBM, tunnel with a railway shuttle;
b) An Upgraded Ferry Link
c) The Base Case augmented by income from an installed HVDC transmission line

The period for planning, design and construction of the facility is 11 years and the operating period examined is 30 years, for a total economic life cycle of 41 years.

Transportation demand projections were developed based on an understanding of the existing markets served. Future potential demand for a fixed link can come from; new developments to attract tourism and induced demand; new economic developments to attract long term commercial vehicle traffic and; major projects that can generate elevated demand for defined periods.

New growth in tourism could result from creation of new national and provincial parks, expansion of tourism infrastructure including accommodations and dining facilities, and successful major advertising campaigns. The Maritimes and Ontario are the largest sources of tourism. Tourism in Newfoundland and Labrador is growing at an increasing rate. The projection, therefore, with or without a fixed link will be to sustain recent trends of 3.5% growth.

Figure 1 shows comparative driving distances and times between Quebec City and St. John's and using the existing Trans-Canada Highway through the Maritimes, using the Trans-Labrador Highway (when completed) to a new fixed link, and using a new Quebec north shore highway (when completed) to a new fixed link. It can be seen that driving distances for travellers using a fixed link would be similar to those on the Trans-Canada Highway.

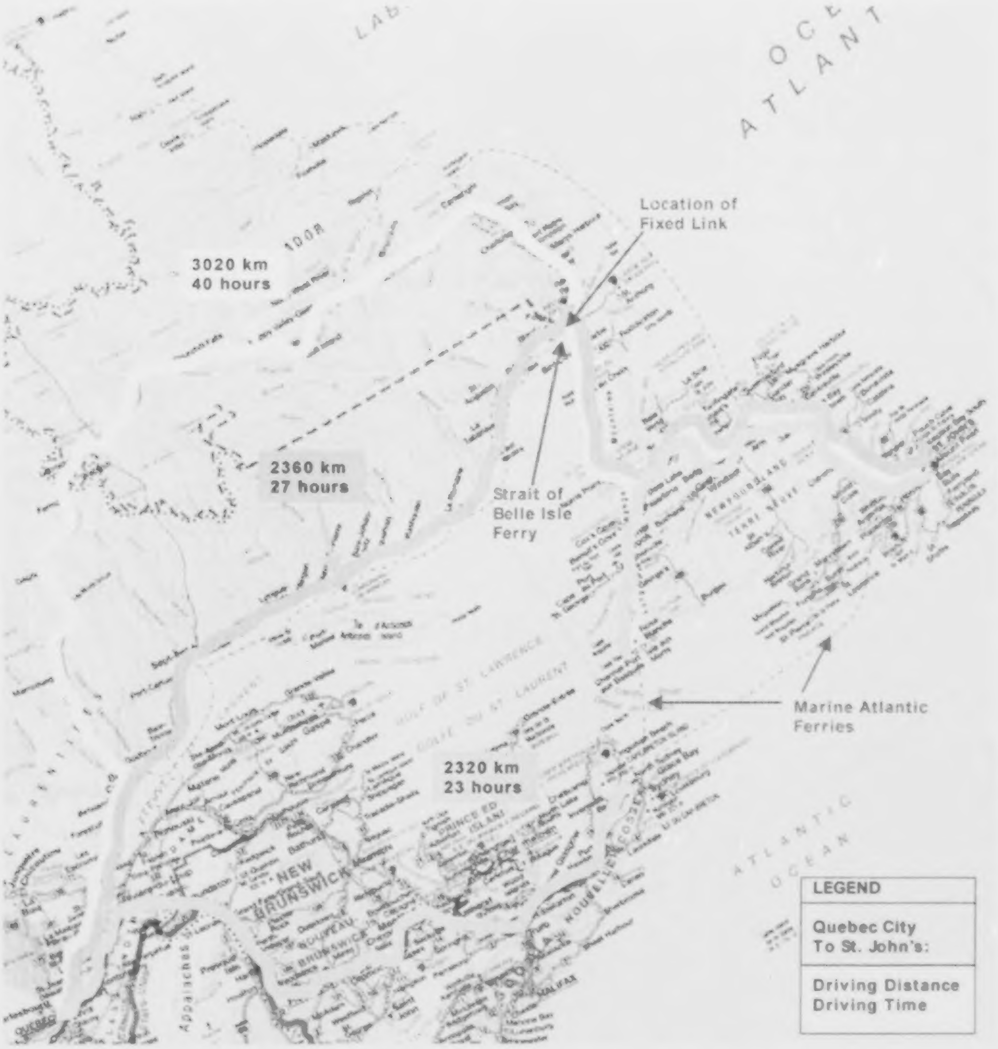
LABRADOR
OCEAN ATLANTIQUE
Location of Fixed Link
3020 km
40 hours
2360 km
27 hours
Strait of Belle Isle Ferry
GOLFE DU ST. LAURENT
GULF OF ST. LAWRENCE
NEWFOUNDLAND
TERRE-NEUVE
Marine Atlantic Ferries
2320 km
23 hours
PRINCE ED. ISLAND
NEW BRUNSWICK
NOUVEAU-BRUNSWICK
NOUVELLE-ÉCOSSE
ATLANTIC OCEAN
LEGEND
Quebec City To St. John's:
Driving Distance
Driving Time

Figure 1 - Travel Distances

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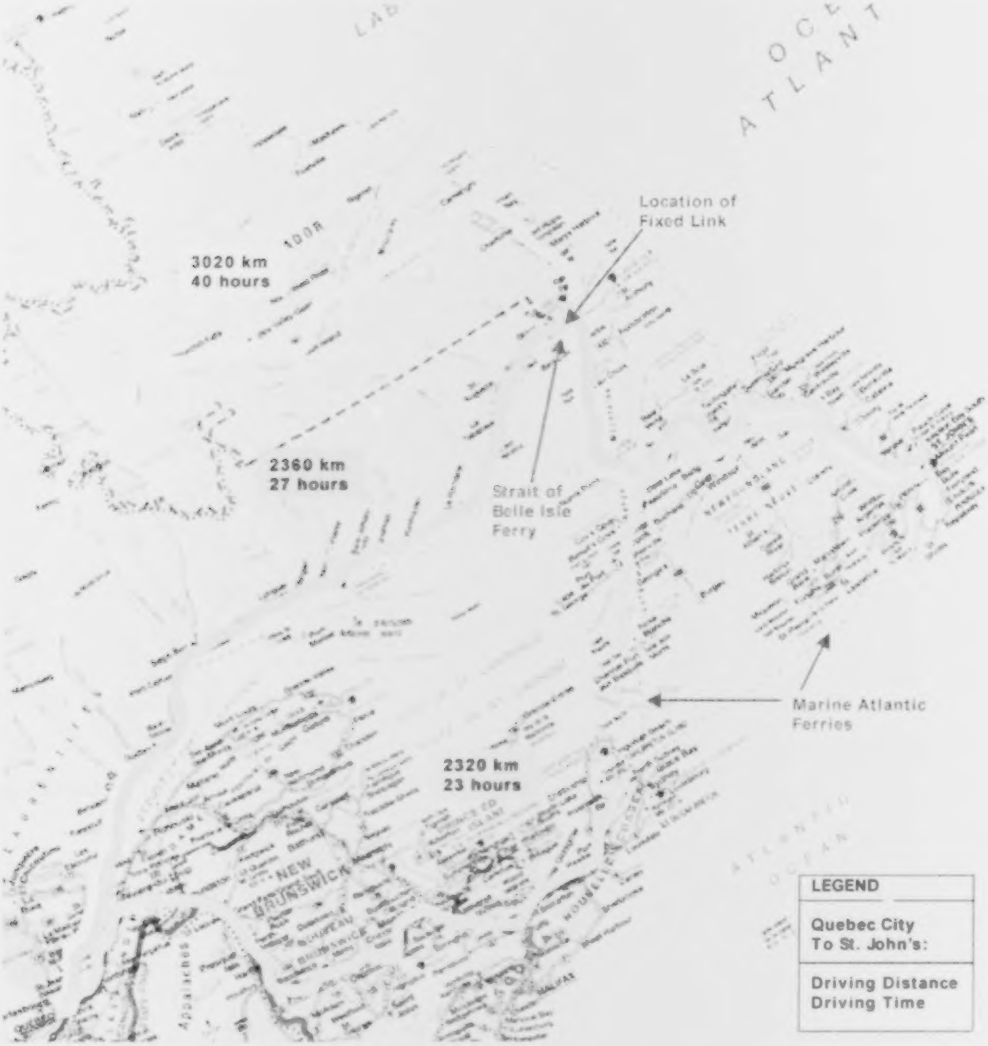
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LEGEND
Quebec City To St. John's:
Driving Distance
Driving Time

Figure 1 - Travel Distances

In determining traffic projection for a fixed link, three types of changes were evaluated.

- One time surge in demand of 30%, primarily affecting local and business traffic;
- One time diversion from Marine Atlantic of 13 % to 15 % to a new fixed link;
- Sustained annual growth of 1.5 % to 4.75 % (depending on type of travellers).

Somewhat more modest increases in traffic were projected for an upgraded ferry.

Revenues for a fixed link and for the upgraded ferry were calculated on the basis of existing *Apollo* tolls. For the augmenting that results from the inclusion of a HVDC cable, the avoided costs were established from costs for a submarine cable, supplied by Newfoundland and Labrador Hydro.

A profile of operations and maintenance costs was developed for the analysis cases. Combining these O & M costs with projected revenues and invoking a discount rate of 7.5 percent (10 percent nominal less 2.5 percent inflation) results in the operating cash flow.

The economic evaluation results are shown in Table 2. Net Present Values (NPV), Internal Rates of Return (IRR) and Benefit Cost Ratios (BCR) are calculated where they are applicable for the cases studied.

Table 2 Economic Evaluation Results

LEVEL	CASE	NPV	IRR	BCR
		$ millions 2004	%	#
Internal Returns	BASE CASE	- 648	- 9.5%	0.07
	HVDC	- 554	-2.1%	0.25
	FERRY UPGRADE	- 164	N/A	0.13
Internal Returns & Economic Returns	BASE CASE	- 559	-5.2%	0.20
	HVDC	- 466	-1.0%	0.37
	FERRY UPGRADE	- 116	N/A	0.38
Internal Returns & Economic Returns & Social Returns	BASE CASE	- 333	-1.3%	0.53
	HVDC	- 240	1.6%	0.68
	FERRY UPGRADE	- 114	N/A	0.39

Sensitivity analyses were undertaken and showed low sensitivity to variations in traffic, high sensitivity to capital costs, relatively low sensitivity to operation and maintenance costs, and high sensitivities to social discount rate and inflation rate.

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Financing Considerations

Because the business case for a fixed link would be difficult to justify on the basis of the results of the economic analysis, any financing arrangements would require an infusion of public funds. This is not unusual in the case of such infrastructure. Of the various potential financing mechanisms addressed in this study, some form of Public Private Partnership (PPP) was considered to be the most applicable.

Conclusions

A tunnel bored using modern tunnel boring machines under the Strait of Belle Isle, at its narrowest point, is the most technically and economically attractive alternative.

The construction cost of a bored tunnel would be approximately $1.2 billion in 2004 dollars. The total development cost for financing purposes, including escalation and interest during construction would be approximately $1.7 billion. The construction period would be six years and an additional five years would be required for planning, additional studies and investigations and environmental assessments, for an overall development period of 11 years.

Based on traffic projections over a 30-year period, the most economic tunnel arrangement would be an electric train shuttle, operating through a single tunnel with staged operation in each direction, that conveys road vehicles on custom-designed rail cars.

The economic and business case analysis showed that a fixed link could not be financed privately under normal economic and business case criteria. This result, however, may be considered not unusual in the realm of public transportation infrastructure.

Including costs and revenue for the transmission lines has an effect on the overall viability of the fixed link. Incorporating the HVDC cables in the fixed link rather than constructing a submarine installation, reduces the capital cost to an HVDC proponent by approximately $390 M. This cost reduction includes the cost of the cable, for which a rental would be charged by the fixed link proponent.

Of the financing methodologies addressed, some form of PPP (Public Private Partnership) arrangement would appear to be the most appropriate. An infusion of approximately $1.4 billion from public sources would be required to make the proposition attractive to the private sector.

1 INTRODUCTION

1.1 Background and Purpose

The concept of providing a fixed transportation link between the Island of Newfoundland and Labrador (and mainland Canada) across the Strait of Belle Isle has been the subject of discussion for many years. Recently, a renewed interest in the concept has developed as a means of making a direct connection with the national highway system and providing a greater degree of integration between the Island of Newfoundland and Labrador.

In early 2004, the Public Policy Research Centre of Memorial University, acting on behalf of the Government of Newfoundland and Labrador and in keeping with its mandate of studying and aiding in the formulation of social and economic public policy, requested a proposal from independent consultants to conduct a study of fixed link concepts at a pre-feasibility level. The objective of the study was "to undertake an independent examination of the economic and technical implications and viability of constructing a fixed transportation link across the Strait of Belle Isle between Labrador and the Island of Newfoundland."

In April 2004, the Policy Centre awarded a contract for the study to Hatch Mott MacDonald. The Atlantic Canada Opportunities Agency (ACOA) and the Government of Newfoundland and Labrador provided financial support for the study. The Policy Centre directed the study with advice from a Project Advisory Committee which consisted of Policy Centre representatives as well as representatives from ACOA, Transport Canada, Government of Newfoundland and Labrador, Newfoundland and Labrador Hydro, and an independent technical advisor.

In keeping with the Terms of Reference the study was undertaken in four distinct phases as follows:

Phase 1 – Background and Research involving a literature review of previous work in the study area as well as of related projects internationally.

Phase 2 – Engineering and Technical Feasibility Options Analysis that entailed the identification and evaluation of alternative fixed link configurations and associated infrastructure, costing, and schedule development. The alternatives to be considered were road and rail tunnels (drill and blast and bored); immersed tube tunnel; bridge and causeway; or various combinations of these alternatives. The relative risks of these alternative concepts were assessed in this feasibility analysis.

Phase 3 - Economic and Business Case Analysis requiring economic analysis, business case analysis, and sectoral analysis of the preferred fixed link option from Phase 2. This phase also required additional analysis encompassing considerations of the economic implications of installing a high voltage direct current (HVDC) transmission, and a preliminary identification of the potential environmental implications of a fixed link. This phase further required the analysis of an upgraded ferry as an alternative to a fixed link.

Phase 4 - Financing encompassing an assessment of potential public and private sector options to develop and operate the proposed infrastructure and the financing arrangements and implications associated with these options

Figure 1.1 is a map of eastern Canada showing the existing transportation connections as well as a proposed fixed link connection to the Island of Newfoundland. The location of the link on this map is the shortest route across the Strait and follows the proposed route in prior power transmission studies. The primary existing connection that would be affected by a fixed link is the ferry service across the Strait of Belle Isle, which is currently seasonal. The route of this service, as well as the ferry services from Nova Scotia to the Island of Newfoundland, is also shown.

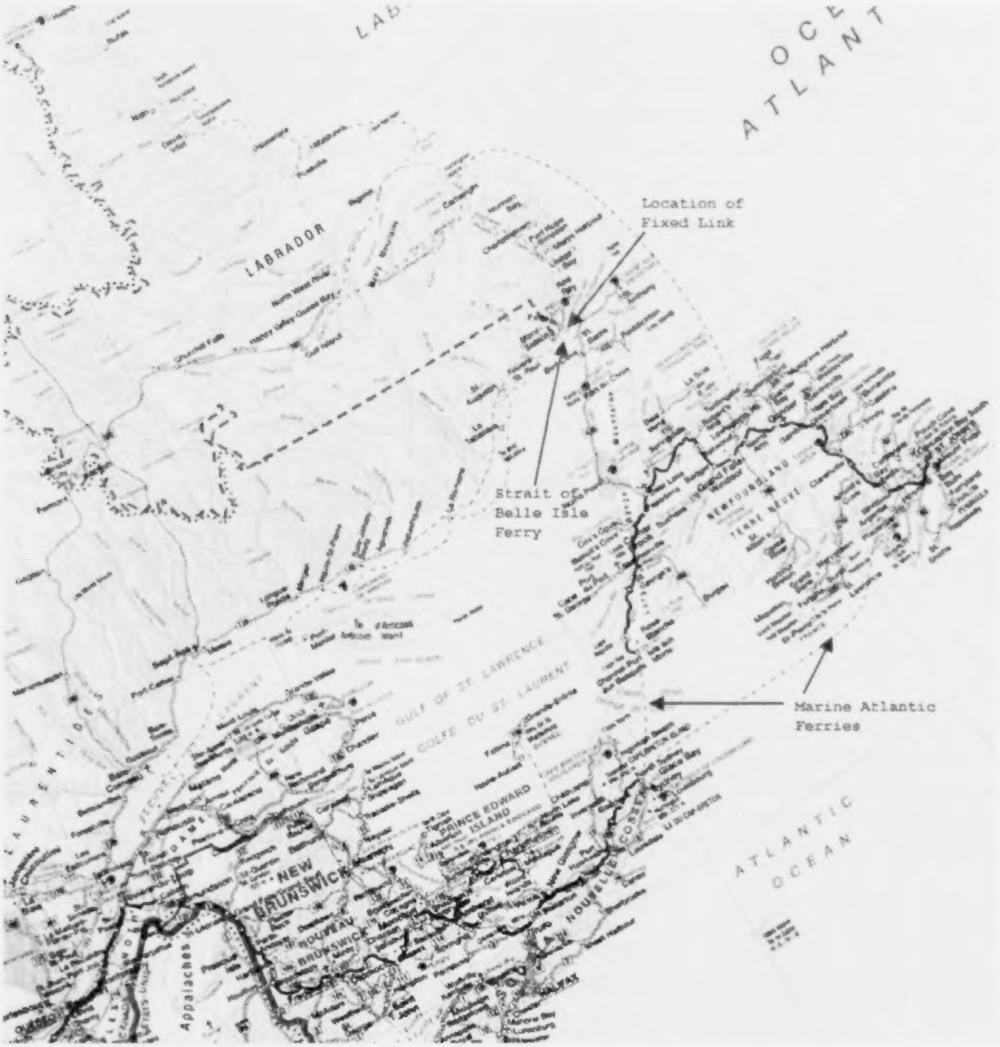
LAB
ATLANT
OC
LABRADOR
Location of
Fixed Link
Strait of
Belle Isle
Ferry
NEWFOUNDLAND
TERRE-NEUVE
GULF OF ST. LAWRENCE
GOLFE DU ST. LAURENT
Marine Atlantic
Ferries
PRINCE EDWARD ISLAND
NEW BRUNSWICK
NOUVEAU BRUNSWICK
ATLANTIC
OCEAN
Appalaches
LAURENTIDES

Figure 1.1 - Location Map

1.2 Overview of Previous Work

The most relevant work in the study area is that carried out over a 10-year period in the 1970's and early 1980's by the Lower Churchill Development Corporation (LCDC). This comprehensive program of site investigations and engineering studies related to the crossing of the Strait for the purposes of electricity transmission from proposed hydroelectric developments on the Lower Churchill River in Labrador. In the early work, the proposed method of carrying the high voltage cables was in a tunnel that would be constructed in the deep Precambrian granite underneath the Strait. At that time, holes were drilled on both the Newfoundland and Labrador sides of the Strait in the locations of proposed tunnel shafts to the depth of this granite layer to obtain geological information. The tunnel was to be created through drill-and-blast methods and by being in this zone; potential problems with water ingress and fragmented rock in the upper sedimentary layers would be avoided. Also, the risk of damage to submarine cables laid on the sea bottom from iceberg scour would obviously be avoided.

By late 1979, however, as more sophisticated studies of the risk associated with iceberg scour problems were conducted and ditching technology became more advanced, it was concluded that a cable crossing route could be selected such that the risk associated with scour of a submarine cable could be reduced to an acceptable level. Additional engineering studies were then conducted for such a cable crossing over a more circuitous route than the straight-line tunnel route from Pointe Amour in Labrador to Yankee Point in Newfoundland.

Throughout the period of these studies, climatic, oceanographic, seismic, and geological/geotechnical data were collected, and detailed engineering assessments, schedules and cost estimates were developed. Some 40 reports were produced. Information obtained from these reports, which were made available to the study by Newfoundland and Labrador Hydro, together with information obtained from other studies done by Newfoundland and Labrador Hydro in the late 1990's and public sources, formed the basis of much of the study background as well as for the development of an understanding of the geology of the Strait and the physical environment of the study area.

1.3 Study Approach

The work was conducted generally according to the phases identified above. On completion of each phase, a meeting was held with the Project Advisory Committee to review progress before proceeding to the next phase. The initial step was to review the prior work conducted by LCDC and Newfoundland and Labrador Hydro, as well as other information in the public domain, in order to understand the study environment and the potential problems inherent in any fixed link across the Strait. Concurrently, a review of relevant fixed link concepts worldwide was undertaken, and potential traffic volumes on a fixed link across the Strait were projected in order to broadly size the link capacity and configuration.

All of the potential concepts for a fixed link were assessed in a preliminary manner, and based on knowledge of the most up-to-date technology, design and costing were taken to a level sufficient to determine whether each concept was practicable and technically and economically viable. Information required for the business case and economic analysis of a fixed link was developed from the relevant sectors of the economy through discussions with government officials, transportation company representatives and Statistics Canada and provincial government department data. Using this information and the engineering estimates associated with the preferred concept, the study team then conducted various financial and economic analyses to determine the overall feasibility of the concept. Potential methods of financing the implementation of such a concept were also addressed.

All of the work was then brought together in this report. The report is structured generally according to the phased approach of the study. Following this Introduction, a review of relevant fixed links worldwide is presented in Section 2; the geology, physical environment of the study area and associated design criteria, as well as a preliminary development of fixed link traffic potential as a basis for link capacity sizing, are addressed in Section 3; the engineering assessment for various link alternatives along with preliminary costing and construction schedules are developed in Section 4; details of the estimate and implementation schedule for the favoured alternative are presented in Section 5; a discussion of the potential regulatory and environmental assessment requirements for the favoured alternative is presented in Section 6; the results of the business case and economic analyses are discussed in Section 7; potential financing approaches are discussed in Section 8; and conclusions are presented in Section 9. Cost estimates and other details are attached as appendices.

2 REVIEW OF RELEVANT FIXED LINKS WORLDWIDE

A review was undertaken of fixed links worldwide that were considered to be of relevance to a fixed link across the Strait of Belle Isle. Fixed links crossing ocean channels and straits comparable to this location were selected. Examples were also selected to illustrate the different types of construction methodologies available for the provision of such fixed links. In general terms, the types are: multiple medium span viaducts or rock fill causeways; long span bridges, either cable-stayed or suspension; and tunnels, immersed tube or bored.

2.1 Øresund Link

The Øresund Link, that opened in 1999, connects Denmark and Sweden across the Øresund Channel. The crossing accommodates a four lane highway and a twin track rail line. The 22 kilometre channel is crossed by a combination of a 16 kilometre bridge and a 6 kilometre immersed tube tunnel (ITT). The tunnel section provides the primary shipping channel. A secondary shipping channel is accounted for by a long cable-stayed span within the bridge section.

The multi-functional requirement of the tunnel suits the low profile rectangular structure that can be easily provided by an ITT, as shown on Figure 2.1. The requirement for both rail and road resulted in a structure approaching 40metresin width that would have been very difficult to accommodate in a bored tunnel configuration. Further, the shallow channel (about 22 metres deep) lends itself to immersed tube construction within the overburden seabed.

The lesson learned from this crossing was that immersed tube tunnels are very applicable to, and efficient for, shallow channels and where the tunnel configuration requires a low profile rectangular cross-section.

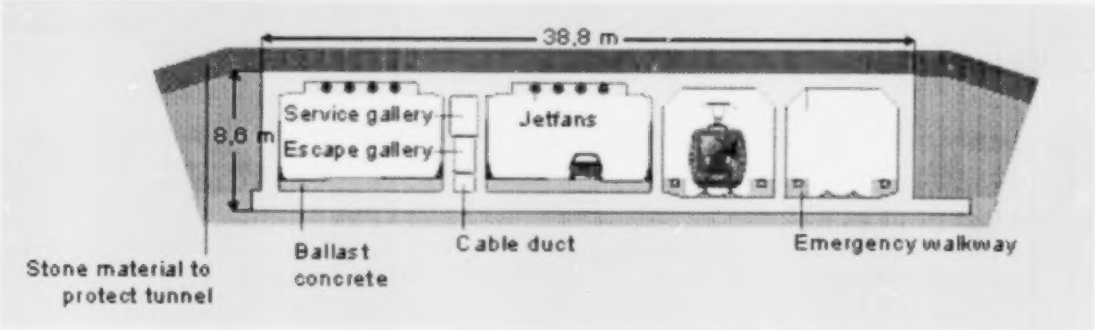

Figure 2.1 - Øresund Link Cross-Section

2.2 Storebælt Crossing

The Storebælt Crossing, as shown in Figure 2.2, between the islands of Funen and Zealand in Denmark opened in 1998 and is part of the highway and rail connection between Denmark and Sweden. Like the Øresund Link, the crossing provides a four lane road and a twin track rail line. The total crossing length of 16 kilometres is comprised of a bridge for rail and road from Funen to a small island within the channel, with a bridge for the road plus bored twin tunnels for the rail line across the primary shipping channel between the island and Zealand. The depth of the channel, at about 60 metres, and the tunnel cross-sections suited to bored tunnels, made an immersed tube tunnel not economically competitive. The twin tunnels are approximately 8 kilometres long and were constructed in overburden below the seabed using earth pressure balance tunnel boring machines.

The lesson learned from the tunnel section was that bored tunnels could be built in very challenging ground conditions. The tunnel construction experienced significant difficulties. It represented an early application of earth pressure balance tunnel boring machines and provided many lessons that have contributed to earth pressure balance TBMs now becoming the standard technique for soft ground and soft rock tunnelling.

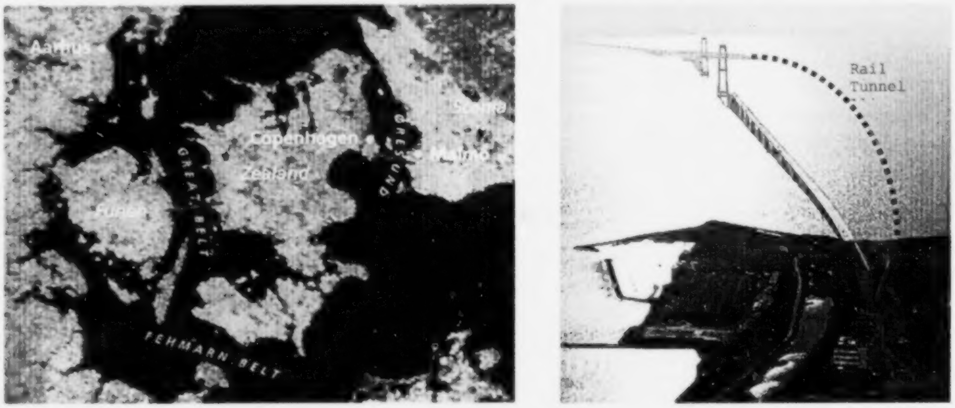

Figure 2.2 - Storebælt Crossing

2.3 Channel Tunnel

The Channel Tunnel, as shown in Figure 2.3, was opened in 1994 and is probably the most famous fixed link in the world. The tunnel is actually three 50 kilometre-long parallel tunnels; two running tunnels carrying rail tracks and one service tunnel for maintenance vehicles and for emergency egress. The tunnels were constructed by tunnel boring machines excavating in a layer of chalk marl that extends across the Channel. The tunnels are used by high speed Eurostar trains operating at 160 kilometres per hour through the tunnel as well as by custom-built shuttle trains conveying passenger cars and trucks loaded and unloaded at the terminals.

The lessons learned from the Channel Tunnel are numerous. The following are considered relevant to this study. The chalk marl was predicted to be an almost ideal tunnelling material. It was expected to be virtually impermeable, to be easily excavated and to stand up generally with a minimum of support. These properties eventually allowed very impressive advance rates to be achieved by the TBMs and the tunnels to be

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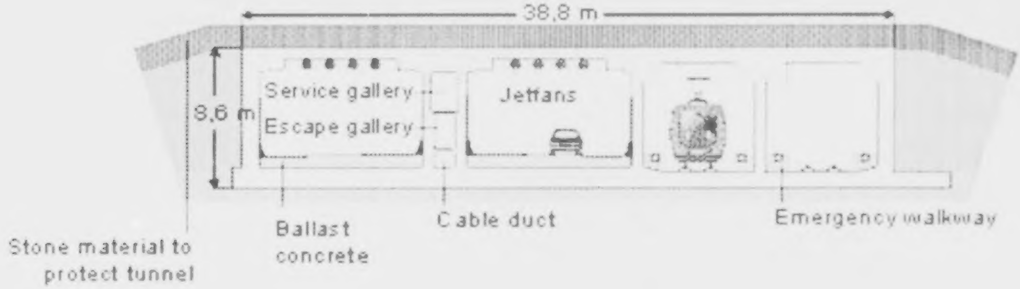

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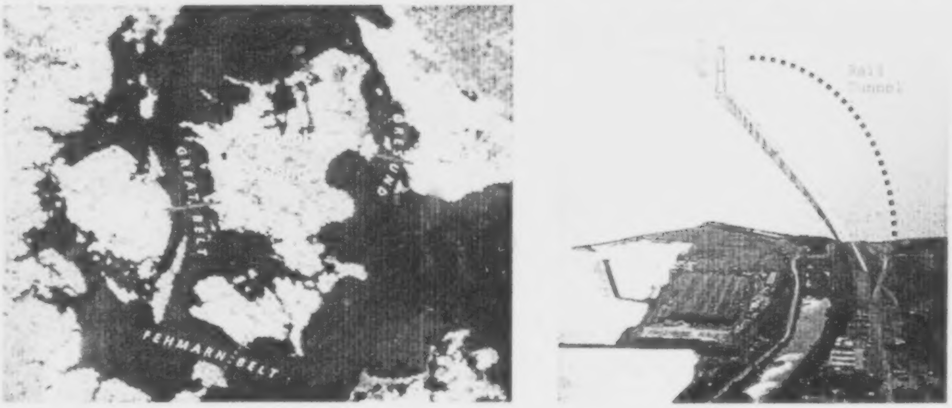

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The lessons learned from the Channel Tunnel are numerous. The following are considered relevant to this study. The chalk marl was predicted to be an almost ideal tunnelling material. It was expected to be virtually impermeable, to be easily excavated and to stand up generally with a minimum of support. These properties eventually allowed very impressive advance rates to be achieved by the TBMs and the tunnels to be completed on schedule even after significant problems at the beginning of the drives where the geology was much worse than expected. At the start of the drives, the marl was found to be blocky and requiring immediate support. The marl was also permeable resulting in significant salt water ingress affecting the performance of the electrical locomotives for muck hauling and reducing the grip on the upgrades at the end of the tunnel. In this zone the choice of an unsealed tunnel lining on the UK side was put into question. On the French side, the marl was expected to be fractured and earth pressure balance TBMs with a gasketted lining were selected. These selections proved to be prudent as difficult ground conditions were encountered and the TBMs dealt with these and the 11 atmospheres of water pressure, albeit with somewhat reduced advance rates.

The Channel Tunnel costs became inflated due to several reasons mostly unrelated to the actual construction. Included in these reasons was the inefficiency of a complex organisation for procuring the project with five French Contractors and five British contractors working for a newly created company called Eurotunnel that had no experience managing a project of this magnitude. Further, the fact that the tunnel connected two countries that had a history of disagreeing created arduous decision processes. These were particularly demonstrated within the vehicle procurement when the shuttle railcars were redesigned many times, greatly increasing their cost and complexity and delaying the operation date for the facility. Therefore the Channel Tunnel cannot be used as a simple comparator to the fixed link proposed across the Strait of Belle Isle due to the size and complexity of the facility as well as the issues described above.

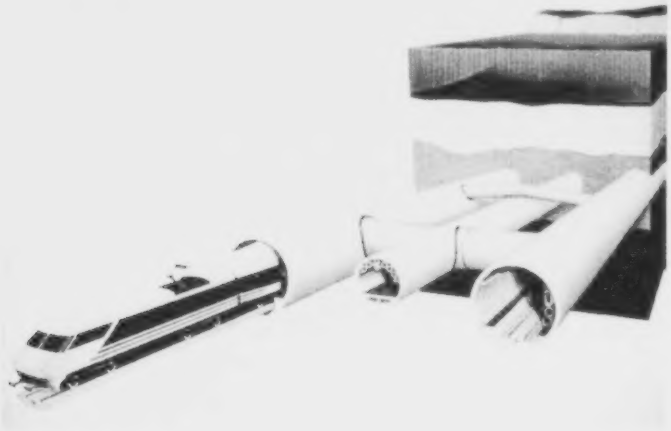

Figure 2.3 - Channel Tunnel

2.4 Lantau Link

The Lantau Link, as shown in Figure 2.4, is a series of bridges to connect the new Chek Lap Kok Airport to the Hong Kong mainland. This relatively short (3.5 kilometres) crossing is a very high capacity facility with two bridge decks, the upper deck carrying a six lane highway and the lower deck accommodating a two track rail line plus two emergency road lanes.

The main lesson learned from this fixed link is that long span suspension and cable stayed bridges can be designed for high traffic capacity and to withstand severe weather conditions in the form of typhoon strength winds.

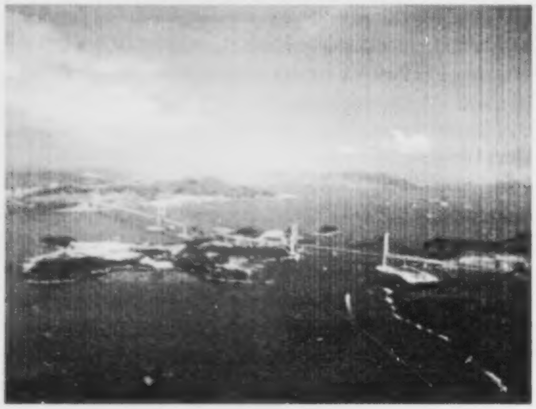

Figure 2.4 - Lantau Link

2.5 Chesapeake Bay Bridge-Tunnel

The Chesapeake Bay, as shown in Figure 2.5, fixed link is a 28 kilometre crossing of the shallow Chesapeake Bay made up of multi-span bridge viaducts connected to an immersed tube tunnel under the shipping channel. The initial crossing was constructed in 1964 as a two-lane road structure. The two viaduct structures were duplicated in 1999 but both presently connect to the single two-lane tunnel.

The major lesson learned on this fixed link is that any structure that limits the depth of the shipping channel should be located to allow for future increases in shipping drafts. The present Chesapeake Tunnel draft will not accommodate the latest Panamax container ships and studies are underway to investigate the lowering of the existing tunnel as well as duplicating the facility. The link also demonstrates that multi-span bridges provide an economical alternative where the channel is reasonably shallow.

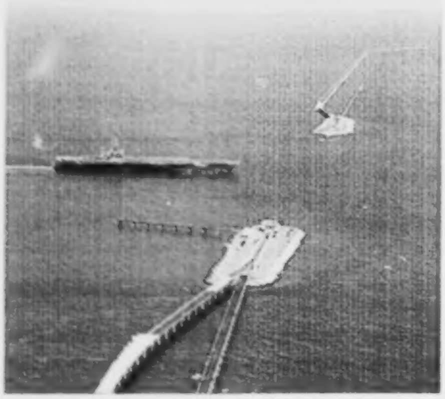

Figure 2.5 - Chesapeake Bay Bridge Tunnel

2.6 Confederation Bridge

The Confederation Bridge, as shown in Figure 2.6, was completed in 1997 and provides a two lane road fixed link between Prince Edward Island and New Brunswick across the 13 kilometre wide Northumberland Strait. This channel is relatively shallow at 30 metres deep and is therefore suited to a multi-span bridge. The limited amount of shipping that uses the Strait is accommodated by a single high clearance long span. The design of the bridge included allowances for ice floe loadings.

This crossing demonstrates that, where conditions are suitable, multiple span bridges can be economical. However, conditions, such as deep water, icebergs and significant shipping traffic, make their application more difficult or even impracticable.

This fixed link is also of interest in that it was built as a largely privately funded project with investment recovery through tolls and annual subsidies from government equivalent to those provided for the ferry it replaced.

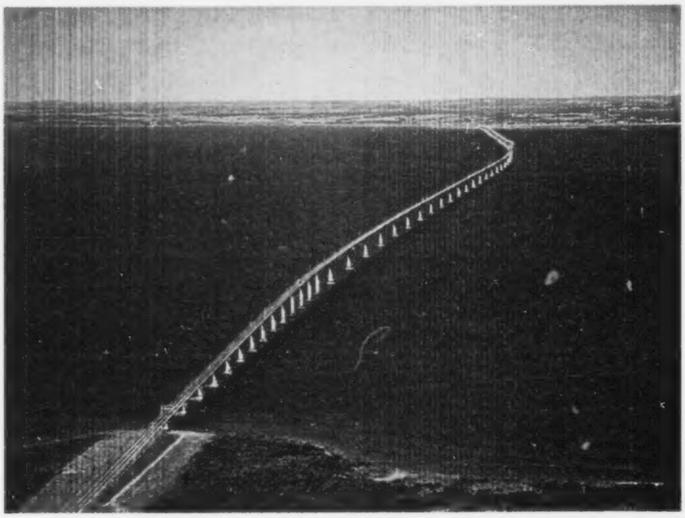

Figure 2.6 - Confederation Bridge

2.7 Summary of Fixed Links

Table 2.1 provides a summary level comparison between the listed fixed links. The data contained in this table has been obtained from published sources and costs have been converted to Canadian dollars using present currency conversions and inflated to 2004 dollars using published inflation rates. Considering this process, the costs in this table should be recognised as being indications of comparative rather than absolute costs.

Table 2.1 - Summary of Fixed Links

	Crossing Length	Water Depth	Vehicles/day	Road	Rail	Rail Passengers/day	Year Opened	Cost $M(2004CAD)	Cost/km $M(2004CAD)
Øresund Link	22 km	30 m	9,300	✓	✓	14,800	1999	4800	300
Storebælt Crossing	16 km	60 m	20,600	✓	✓	30,000	1998	7700	430
Channel Tunnel	50 km	50 m	8,300		✓	17,600	1994	34400	690
Lantau Link	3.5 km		40,500	✓	✓	250,000	1997	2300	660
Chesapeake Bay Bridge/Tunnel	28 km	30 m	8,800	✓		-	1964	2000	75
Confederation Bridge	13 km	30 m	N/A	✓		-	1997	1200	90

2.8 Other Relevant Tunnels

Also of relevance to this study are two tunnels recently constructed in Europe. These are the Vereina Tunnel in Switzerland and the Laerdal Tunnel in Norway. These are both tunnels of significant length for relatively low traffic applications. The Laerdal Tunnel is the longest road tunnel in the world. This two lane tunnel was constructed by drill and blast techniques through gneiss. The Vereina Tunnel has a single track rail shuttle for conveying road vehicles. This tunnel was constructed partially by drill and blast and partially by tunnel boring machine, again in gneiss. Both these tunnels demonstrate the ability in Europe to build low cost tunnels. Table 2.2 shows the features of these tunnels.

Table 2.2 Other Relevant Tunnels

	Crossing Length	Vehicles/day	Road	Rail	Rail Passengers/day	Year Opened	Cost $M(2004CAD)	Cost/km $M(2004CAD)
Vereina Tunnel	19 km	1500		✓	4000	1999	440	23
Laerdal Tunnel	25 km	1000	✓		-	2000	245	10

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3 THE PHYSICAL ENVIRONMENT OF THE STUDY AREA AND DESIGN CRITERIA/CONSIDERATIONS

3.1 Climate

The climate of the study area is influenced by the continental landmass, the Gulf of St. Lawrence and the North Atlantic. Conditions are very variable and may fluctuate rapidly over short periods. The Strait is notoriously foggy during summer with generally poor visibility in July and August.

Air Temperature

Long term temperature data are available from stations at St. Anthony and Flower's Cove (on the Island) and Battle Harbour (in Labrador). The mean daily temperature in summer is about 13° C with mean maximum being 17° and mean minimum being 8° C. The maximum recorded temperature is 30° C at St. Anthony on August 11,1995. Daily mean temperature in January and February is –10° C with the maximum and minimum daily means being –6° and –16° C respectively. The extreme minimum on record is –34° C that was recorded at Flower's Cove on February 4, 1995.

A reasonable minimum design air temperature is –30° C. The one per cent design temperature in the National Building Code for St. Anthony is –27° C.

Precipitation

The month with the greatest precipitation and magnitude varies from station to station, the highest mean monthly figure being about 125 mm at St. Anthony in September. The extreme daily rainfall, also at St. Anthony, is 88 mm occurring on September 2, 1999. The mean annual precipitation is about 1200 mm. Mean annual snowfall is approximately 400 cm and mean snow depth over the winter months is about 50 cm. The design ground snow loading for St. Anthony based on factors in the National Building Code is 4.2 kPa.

Winds

Maximum hourly wind speed recorded at St. Anthony is 97 kilometres per hour and maximum gust speed is 148 kilometres per hour. Prevailing directions are southwest in summer and northwest in winter although in April, northeast winds are more common. The 1 in 100 year design hourly wind pressure for St. Anthony from the National Building Code is 1.01 kPa.

Degree Days

Freezing degree days (below 0° C), which are indicative of ice growth potential, are 1323 at St. Anthony and 1166 at Flower's Cove.

Icing

Icing of above-water structures can occur from both atmospheric and sea spray icing and would be a consideration for bridge superstructure components and, to a lesser extent, for riprap sizing related to the causeway concept. There is literature in the public domain on both types of icing; freezing precipitation studies generally pertain to transmission and communications lines and towers, while sea spray icing pertains to oceangoing vessels. Both types of icing may occur in the area.

Newfoundland and Labrador Hydro has done significant work on freezing precipitation on the Great Northern Peninsula and in Labrador. For the study area, they recommend a design value for rime icing of 11.5 cm of radial ice on transmission lines combined with a maximum wind gust of 115 kilometres per hour.

Chaine and Skeates (1974) computed accumulations of ice on various surfaces as a function of return period for a number of locations in Canada. For St. John's Airport, the ice accumulation for a 50-yr return period was calculated to be 5.3 cm on a horizontal surface, 6.3 cm on a vertical and 3.1 cm on a 25 mm radial conductor.

A report by NORDCO (1981) on icing of a stationary, floating offshore oil platform on the Grand Banks presents a relationship between sea spray icing and height of a platform component above sea level. The authors conclude that sea spray icing would not affect components that are more than 1.5 times the wave height above the wave crest, or 15metresfor a wave height of 10 m. In all likelihood, potentially vulnerable components of a bridge across the Strait would be higher than this.

3.2 Oceanography

Bathymetry

Detailed bathymetry of the study area was compiled from a number of surveys during the proposed Lower Churchill Development of the late 1970's and early 1980's. (Woodworth-Lynas, et al, 1992) In this work, five physiographic zones were defined. The Labrador Coastal Zone consists of the northwestern slope of the Labrador Trough (with depths of up to 115metresand width of 1 to 2 kilometres) and has generally uniform slopes of 6 to 12 per cent; Centre Banks South and North with depths from 15 to 85 metres are separated by a narrow depression 85metresdeep; the Newfoundland Trough is 5 to 12 kilometres wide and from 70 to 125 metres deep; and the Newfoundland Coastal Zone, that is bounded by the coast and a linear escarpment separating it from the NF Trough. Figure 3.1 shows bathymetric contours within the intended locality of the proposed Fixed Link.

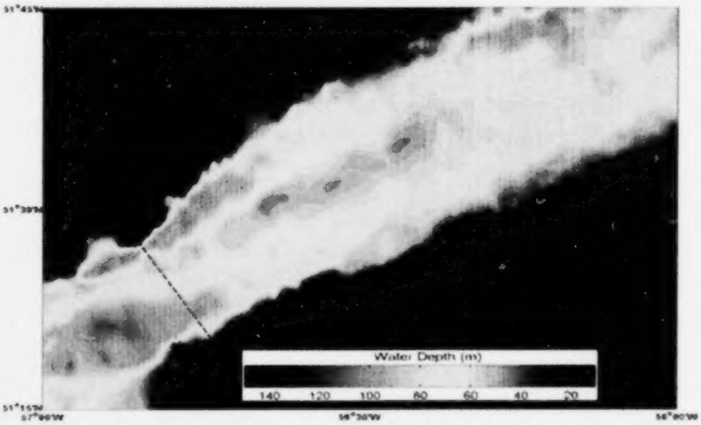

Figure 3.1 - Strait of Belle Isle - Bathymetry

Currents

The earliest record of current measurements in the Strait as reported by Ingram (1982) is that of Dawson (1907,1913) who made rough measurements from a vessel without the aid of modern self-recording current meters. Dawson reported that the dominant flow within the Strait was inward toward the Gulf of St. Lawrence along the Labrador side and in the opposite direction along the Island of Newfoundland side. The first significant program of current measurement was in 1966 by the Bedford Institute of Oceanography (BIO) and as reported by Farquharson and Bailey (1966). With meters installed across a line from Pointe Amour to Savage Point, they found that the mean flow of water consisted of a surface flow (to the Atlantic) on the south side and a compensating inflow at the surface on the north side and in the subsurface waters on both sides. In 1980, BIO conducted another program of current measurements along the same cross-section with meters placed at 15 metre and 50 metre water depths. The results of this program, according to Ingram, suggest that the maximum current when all components are combined (during spring tides) are as follows:

15 metres depth	3.6 metres per second (7.2 knots)
50 metres depth	2.5 metres per second (5.0 knots)

Other current measurement programs in 1978 and 1979 in support of a proposed submarine cable crossing did not result in any more conclusive results on the current regime in the Strait. These and the drilling programs associated with the same proposed development did show, however, that with appropriate equipment, it is possible to work in the Strait during the summer and fall periods.

Waves

Wave data were collected in the study area in 1979 and 1981 and wave contour charts were obtained from the Meteorological and Oceanographic Centre for Newfoundland Waters as part of the studies to support the cable crossing. A wave hindcast analysis was also carried out. The results of this work indicated that, during the period June through August, the significant wave height would be less than 3 metres, and waves with heights of 2 metres or more would occur for less than 2.5 per cent of the time. Waves with heights of 1 metre or greater would occur 40 per cent of the time. During winter, wave height will be affected by the amount of sea ice in the Strait as well as in the Labrador Sea and Gulf. Assuming no ice cover, the maximum wave height with a return period of 100 years would be approximately 10 metres and would occur in January. (SNC-Lavalin,1982).

3.3 Sea Ice

Sea ice in the Strait is a combination of locally formed ice and pack ice that drifts down from the Arctic and Labrador Sea. The thickness, configuration and strength of this ice pack change with time as individual ice floes collide, freeze together, raft and ridge with changes in the current and wind. While the thickness of an individual floe that forms solely due to thermal effects would generally be less than 1 metre, this collision interaction results in formations that can be many metres thick but the average strength of such formations will be less than that of a homogeneous sheet of ice which would have a compressive strength in the order of 2 MPa. The forces that such an ice pack might exert on a structure depend on the areal extent of the ice feature, the prevailing winds and currents, the thickness and the strength of the ice feature, and the configuration of the structure with which the ice interacts.

With respect to the extent and concentration of ice in the Strait, on average, local ice first forms in mid to late December. In January, the Labrador pack drifts into the area and by late January, the coverage is seven to nine tenths. Full ten-tenths coverage may happen in a severe year and may last for up to six weeks. The pack usually moves in and out of the Strait with the current and wind and only a small proportion of it moves into the Gulf proper. However, during persistent northeast winds, ice has been known to drift into the northeast arm of the Gulf.

Navigation by oceangoing vessels in the Strait normally continues into January although in a severe year navigation can become impeded by mid-December. Normally, navigation resumes in May although the ice may linger well into June. Local ferry operations are generally suspended from mid January to early May.

Several studies and at least one field measurement program of near shore ice conditions were conducted in support of the proposed cable crossing in the 1970's and early 80's. Thicknesses of undisturbed ice close to shore were generally less than 0.6 metres while rafted and rubble formations were several metres thick. No thickness measurements were made further out in the Strait because the central concern was the effect of ice on a submarine cable and appurtenances at the shoreline. An understanding of such thicknesses may be obtained, however, from programs conducted further north in the Labrador Sea, and in the Northumberland Strait with respect to the Confederation Bridge crossing to Prince Edward Island. In addition, information on the experience with ice around the Confederation Bridge piers since construction may be instructive in predicting ice-structure interaction behavior in the Strait of Belle Isle.

3.4 Icebergs

The origin and movement of icebergs in eastern Canada are generally well understood. For the purposes of this study, the concerns are with the potential for scouring and collision with bottom-founded structures. Scouring is a concern only for an immersed tube tunnel alternative crossing concept that would have shallow burial or be covered by armour stone.

A number of studies were conducted on the iceberg scour question in the 1970's and early 1980's in consideration of a submarine transmission cable from the proposed Lower Churchill development. A fundamental question relates to the potential for seabed scour at depths greater than 70 metres southwest of a shoal that is 45 kilometres upstream of the proposed crossing line. This subject is discussed at length in Woodworth-Lynas, et al (1992) and is summarized here.

Of the average of 600 icebergs that pass the latitude of the Strait each year from Baffin Bay to the Grand Banks, 60 to 90 drift into the Strait, the largest number being seen in May and June. Most of these enter on the Labrador side and exit on the Island of Newfoundland side in concert with the prevailing currents. A few of these icebergs (estimated at 6 to 12 with drafts of less than 55 metres) move into the Gulf and ground along the Quebec shore. (A few have been known to penetrate to Anticosti Island or the Bay of Islands area. One small berg reached the Cabot Strait in 1960 before melting.) The greatest number of icebergs observed in the Strait at one time was 496, recorded by the Belle Isle lighthouse keeper on May 30, 1858.

The shoal area previously mentioned was thought to act as an iceberg filter and prevent any deeper icebergs from drifting into the proposed cable crossing area. However, scours in deeper water further into the Strait have been observed, causing this theory to be questioned. A number of researchers have postulated that because icebergs roll, the previous draft may increase thereby permitting the iceberg to contact the seabed in water deeper than 70 metres. Risk analysis studies commissioned as part of the Lower Churchill program of work have suggested that the probability of an iceberg scouring along the proposed cable route is 0.5 events for every 100 icebergs in water depths greater than 75 metres and 0.1 events per 100 icebergs in depths greater than 85 metres. In the engineering studies of the cable crossing, the concept was to trench and bury the cable out to a water depth of 85 metres. While there is some doubt about the risk associated with scour, there is also no data on the depth of scour in the area thus making a recommendation of burial depth difficult. However, there is such data from other areas and reasonable extrapolations should be possible. In recent years, significant work has also been done on the subject relating to the protection of seabed equipment on the Grand Banks.

For the purposes of the current study, researchers at C-CORE undertook an analysis of the iceberg scour risk in the Strait of Belle Isle. Iceberg scour risk and required cover depths were determined for an underwater structure running from Yankee Point in the Island of Newfoundland to Pointe Amour in Labrador. Grounding rates were determined using a grounding model that uses mean iceberg drift speed, iceberg keel depth distribution, iceberg frequency, water depth and seabed slope. Iceberg drift speed was based on 21 iceberg trajectories collected off Pointe Amour in 1979 and 1980. (Iceberg monitoring programs were conducted by LCDC over several years). Iceberg frequency was determined from an analysis of Canadian Ice Service iceberg charts from 1988 to 2004. Iceberg keel draft distribution was based on observed iceberg waterline length data collected off the coasts of Newfoundland and Labrador. Water depth and seabed slope were determined using data from a bathymetric chart.

The results of the grounding model were then used to determine iceberg risk using iceberg scour and pit data from the White Rose region of the Grand Banks. Required clearances between scouring and pitting iceberg keels were based on pipeline risk analyses from the same site. Figure 3.2 illustrates the required cover depths over the top of the tunnel as function of the mean return periods of 100 and 1000 years to prevent damage from scouring and pitting icebergs. The required cover depths over the top of the tunnel are 3 and 5.5 metres for return periods of 100 and 1000 years respectively, to prevent damage from scouring and pitting icebergs.

C-CORE's report on the analysis of iceberg scour risk in the Strait of Belle Isle is provided in Appendix B.

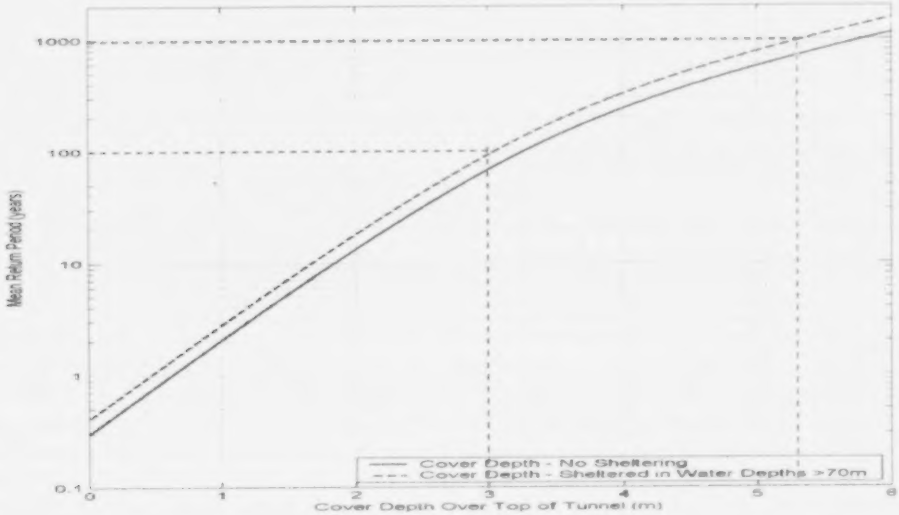

Figure 3.2 - Required Cover to Top of Tunnel to Prevent Iceberg Damage

3.5 Geology

An understanding of the geology of the Strait and adjacent coastal areas is obviously fundamental to the tunnel concept. The following description addresses both bedrock and surficial geology of the area.

Bedrock Geology

Strait of Belle Isle

The Strait of Belle Isle forms the northern extremity of the St. Lawrence Lowland and lies within the Canadian Appalachian region. The St. Lawrence Lowland is bounded on the Newfoundland side by the Highland of the Great Northern Peninsula and Long Range Mountains, and on the Labrador side by the Labrador Highland and Mecatina Plateau.At the narrowest width of the Strait, between Pointe Amour, Labrador and Yankee Point, Newfoundland, where the distance from shore to shore is about 18 kilometres, the area is underlain by a vertical succession of sedimentary rock strata of Cambrian age overlying Precambrian basement rock. The northern Newfoundland region has been subject to sedimentation, volcanism and orogenesis resulting in the crossing area being extensively faulted and forming a possible collapse structure. Figure 3.3 shows an inferred geological section between Pointe Amour and Yankee Point.

The basement rocks under the Strait, in Labrador, and under the Northern Peninsula are Precambrian in age. They belong to the Grenville Province and consist of a complex of metamorphic and granitic rocks. On the Newfoundland side, the complex forms the Long Range Mountains where it consists of schists and gneisses. These rocks are cut by several granitic and gabbroic intrusive and by numerous steeply dipping diabase dykes striking northeasterly. On the Labrador side, the Precambrian Metamorphic Complex forms the Mecatina Plateau. The Complex is a large area consisting of granite and granodiorite intrusives and extends from the Atlantic Ocean to beyond the Provincial Boundary.

The contact between the Paleozoic sedimentary and the Precambrian rock strata is an angular unconformity. It occurs about 95 metres below the Labrador shoreline and about 460 m below the Newfoundland shoreline. Although the contact dips gently southerly between the above two points, it is frequently offset vertically by extensive faulting occurring in the Strait.

The sedimentary rock strata overlying the Precambrian basement rock in the crossing area are Cambrian and Ordovician in age. Their total thickness elsewhere is greatly in excess of 500 metres. These strata are nearly flat-lying or gently dipping southerly and are composed of sandstones, dolomite, limestone and shale.

The sedimentary rock strata and the Precambrian basement rock have been faulted extensively as indicated in previous off-shore seismic work and field mapping during 1975. Seismic interpretative results infer that fourteen faults are present in the rock beneath the Strait between Yankee Point and Pointe Amour. The predominant set of faults strikes northeasterly parallel with the direction of the Strait. These faults have vertical offsets as is typical with normal or reverse faults. Six of the faults are located in the vicinity of the Labrador trough along the north side of the Strait and more or less parallel with the shore. Less prominent faulting occurs striking at right angles to the first set. Joint sets generally follow the fault pattern.

The entire Strait has been extensively glaciated during Pleistocene time and such features as glacial till, erratics and striations are common on the seabed. The overburden is generally composed of sand, gravel, cobbles and boulders. It appears to be generally shallow and more or less uniformly distributed throughout the area.

Bedrock outcropping is frequent. A more recent deposition of a thin layer of shells and shell fragments overlies the soil and bedrock in many places on the floor of the Strait.

Labrador (Pointe Amour)

From 1973 to 1975, field mapping and drilling programs were conducted in the area of shaft locations on both sides of the Strait. Mapping on the Labrador side indicated that a vertical succession of nearly flat-lying Cambrian sedimentary rock strata totaling about 170 metres in thickness overlies the Precambrian basement rock. The sedimentary rock formations are composed of about 75 metres of interbedded limestones and shales belonging to the Forteau formation. These strata overlie about 92 metres of arkosic sandstone and orthoquartzite with minor siltstone and conglomerate of the Bradore formation.

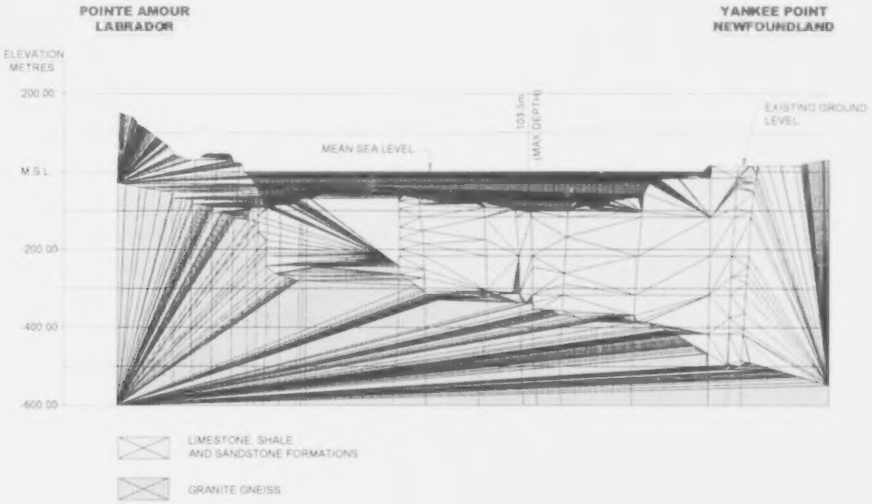

Figure 3.3 - Inferred Geological Section Between Pointe Amour and Yankee Point

The whole assemblage of sedimentary rock is down faulted along northeasterly trending faults strata in a series of blocks from inland to the vicinity of Pointe Amour at the shoreline. The Forteau and underlying formations are extensively faulted at Fox Point, about 1 to 2 kilometres east of Pointe Amour. The underlying Precambrian basement complex is composed of granitic gneisses and schists and intrusives of granitic composition. Surficial examination of the Forteau limestone exposures in the Pointe Amour area indicated that these strata are nearly flat-lying or dip at a maximum of 2 to 5 degrees north or south.

During 1973, a borehole was drilled at Pointe Amour to a depth of 151 metres and intersected Precambrian gneiss at a depth of 118 metres. An additional hole was drilled 151 metres west of the first Labrador hole to a depth of 301 metres in 1974; this hole terminated in gneiss. Although not drilled to the bottom elevation of the shaft at 560.5 metres the Precambrian granite gneiss is expected to continue with depth to this point and below.

Mapping of the shaft rock from an 8.5 metres deep excavation and examination of rock core recovered during drilling indicated that although there exists a slight inclination of the beds to the north or south, the strata are essentially horizontal or sub-horizontal at this location.

Seepage into the shaft collar was reported at two points, one at 1 metre depth and the other at 3.8 metres depth. The rate of inflow was estimated to range from 113 litres per minute following periods of rainfall to 9 litres per minute under normal condition and zero litres per minute during late winter.

Two sets of fractures varying in thickness from about 1 mm to about 8-10 mm were observed in the shaft collar rock. These fractures decreased in frequency in depth. The first set is subvertical with a strike and dip about parallel with the usual fracturing on surface rock. The second set is subhorizontal and reported to be very nearly parallel to the bedding.

Core recovered from the Lower Forteau indicated a high interbedded shale content in the rock from the excavated shaft collar to the top of the Bradore formation varying from 20 percent to 80 percent but averaging about 50 percent, estimated. At three locations, interbeds of pure shale were observed in thicknesses ranging from 300 mm to 500 mm. The rock throughout was generally dense and fresh except at a depth of 10.9 to 14.0 metres where the rock had a weathered appearance. At surface, trenching near the shaft area indicated that weathered shale was present. Permeability of the rock was estimated to be low.

A water-bearing zone was reported at about mid-point of the Bradore Formation between depths of 68 to 94 metres. In the contact zone between Bradore and the underlying Precambrian, a zone of very soft volcanic rocks 7 metres thick was reported.

The Precambrian complex is composed of gneisses, schists and granitic intrusives rocks. The gneisses are composed of feldspar, quartz and variable amounts of mica (muscovite and biotite). The schists are mainly micaschists. The gneiss extended from the base of the altered volcanics to the bottom of the borehole at el 301 metres. The rock is dense and fresh and displays foliation of gneissosity at an inclination of 20°, 30°, 70° and 85° fractures. Eighteen fractures zones were reported. Of these, over 70 percent occur at intervals over a vertical length of 85 metres between depths of 182 and 267 metres below surface. Of the total number of fractures, about one-third showed evidence of weathering or alteration. Of the total number of fractures, 15 percent are present to 15 metres below the top of the formation and the remainder occur in the lower 120 metres, thereby leaving a vertical distance of almost 50 metres in which very little fracturing was reported.

Island of Newfoundland (Yankee Point)

The bedrock strata on the Newfoundland side are overlain by a thin layer of peat and grassland covering glacial deposits of sand and gravel containing rock fragments in size from a few millimeters up to 500 mm. The thickness of the overburden increases from a metre or so near the shore to about 3 metres inland. At Yankee Point bedrock is present about 2.5 metres below ground surface. Sedimentary rock strata (Hawke Bay, Forteau and Bradore Formations) extend from the bottom of the overburden 460 metres down to the gneiss. At the contact between the sedimentary rock and the gneiss, about 7 metres of altered volcanics or metasediments occur and these are included with the Precambrian at the top of this formation.

The almost flat-lying sedimentary rock strata of the Hawke Bay Formation outcrop along the shore at Yankee Point and overlie a vertical succession of sedimentary rock strata totaling 460 metres approximately. This series is composed of granite gneiss, feldspathic gneisses and mica gneisses. Normal and reverse faulting is present with the downthrown sides mainly in the direction of the Strait. Downthrusted and upthrusted blocks along these faults have been interpreted as typical of the faulted stratigraphy of the Strait.

During 1973 a borehole was drilled at Yankee Point to a depth of 197 metres in 1973, deepened to 396 metres in 1974 and further deepened to 546 metres in 1975, intersecting the Precambrian gneiss at 469 metres. The shaft collar was excavated to a depth of 15 metres in interbedded dolomitic limestone, dolomite and shale of the upper Hawke Bay Formation. These strata are horizontal, the rock at this depth consisting of crystalline limestone (54%) shaley limestone (40%) and shale (6%). The limestone beds in the uppermost 5 metres range in thickness from 50 mm to 500 mm. The shaley limestone beds average 100 mm in thickness and contain 30 percent shale and 70 percent limestone. Grey shale lamellae range in thickness from 1 to 10 mm. Inflows into the shaft collar rock occurred at 5 metres, 7 metresand 11 metres below surface approximately at shale/limestone contacts. Inflow rates were 34, 6 and 0.5 litres per minute respectively. Fractures occur in two sets, one set parallel with the bedding and the other normal to the bedding. The frequency of the fractures was found to be greatest in the top 3 metres of the shaft collar.

Below the collar excavation, borehole cores indicated that interbedded dolomite and shale extends for a depth of 72.4 metres. The carbonate rock contains an estimated 80 percent dolomite or dolomitic limestone, 18 percent shale and 2 percent shaley limestone or limey shale. The strata appeared to be horizontal or nearly so and relatively unfractured. Shales occur mainly in the uppermost 40 metres of the formation. The rock was generally dense and fresh throughout. Permeability throughout this dolomitic formation was estimated to be low although some inflow might occur at a depth of about 60 metres where return water was lost during the borehole investigation.

Underlying the carbonate section is the lower 155 metres thick section of the Hawke Bay Formation composed of sandstones, orthoquartzites and shales. These strata appear to be flat lying. Individual bed thicknesses where no shale occurs range from an estimated 150 mm to about 450 mm. Prominent shaley beds occur at depths of 79-87, 115-124, 164-170 and 180-188 m. Other less distinct shaley strata are also present. Two sections of sandstone and/or orthoquartzite occur at 139-149 metres and 170-180 metres. These beds are very strong and massive and contain little or no shale. At the bottom of the formation, sandstone breccia about 5 metres in thickness is present along with evidence of slickensides and fault gouge dipping 20-60°, indicating that faulting is present at this point. In this respect, fractures in the rock are present at several locations extending from about 9 metres above the contact with the underlying Forteau formation to about 15 metres below the contact and these may be associated with the possible faulting or other movement along the strata in this location. The rock throughout this lower section of the Hawke Bay is dense and fresh and only slightly fractured except as noted above. Permeability was estimated to be low for the most part throughout but may be low to medium at 72-115, 139-197, and 218-222 metres.

The Forteau (dolomitic) limestone and shale formation underlies the Hawke Bay sandstone. The formation is composed of an estimated 66 percent limestone and 34 percent shale. Borehole cores indicated the limestone beds to be fairly massive and occasionally may reach a thickness of 300 to 900 mm thick in the uppermost 40 metres of the formation in those individual beds where shale content is low or absent. In the uppermost shale layer located immediately below the contact with the overlying Hawke Bay sandstone, some fracturing occurs with slickensides at 40-60°. At a depth of 337 metres, some fault gouge was reported with an oblique fracture at 40° and slickensided. Rock core recovered from this formation contained very few fractures below a depth of about 15 metres below the top of this formation. The Forteau rests conformably on the underlying Bradore Formation.

The Forteau limestone and shale is generally dense and fresh and its permeability is estimated to be low. At a depth of 245 metres, artesian salt water with gas bubbles was encountered with an average inflow rate of 54 litres per minute and a back pressure on the water feed hose of 827 kPa (120 psi) after 12 hours of capping.

The Bradore formation is 121 metres thick and deposited unconformably on the underlying Precambrian. It is 28 metres thicker than the Bradore in the Pointe Amour shaft location. It is possible that much of the increased thickness on the Newfoundland side occurs above the contact with the Precambrian where the conglomerate content appears to be greater. As on the Labrador side the rock strata were found to be generally dense and fresh. Whereas joint fractures parallel to the bedding in the Labrador shaft location have been reported as being frequent to numerous and more or less uniformly distributed throughout the Bradore, in the Newfoundland shaft rock these joints were found to occur mainly in the lower half of the formation only. Estimated permeability ranges from low to medium. Bed thicknesses are probably similar to those in the Labrador shaft and shale is present in the uppermost 5 metres of the formation directly below the Forteau. The siltstone content is probably similar to that on the Labrador side of 2 percent. At the bottom of the formation close to the contact with the underlying Percambrian, a prominent gypsum horizon is present.

About 77 metres of the Precambrian quartz-feldspar-biotite gneiss was cored at Yankee Point. The rock was found to be dense and fresh and displayed foliation or gneissosity at an inclination of 40 to 60° (true dip). A possible shear zone 600 mm thick is located 3.6 metres below the top of the gneiss. A large number of factures and planes of weakness were reported, almost 90 percent of which are inclined at angles varying from horizontal to 20°. Of the remainder, 8 percent are inclined at 45°. The number of fractures per unit length was found to be much greater in this gneiss than that in the Labrador core. In the lower half of core recovered, a high percentage of the fractures was reported to have fresh or clean breaks so that the fractures may be reasonably tight in rock that has not been disturbed by superimposed mechanical forces such as drilling. Only one fracture of the total number was reported to exhibit slickensiding.

Surficial Geology

An understanding of the surficial geology is needed for an assessment of the immersed tube tunnel concept as well as for the nearshore and offshore excavations for the tunnel approaches.

Additional information to that obtained in the programs reported above was obtained as a result of a borehole program carried out in 1981 along six potential submarine cable routes (as opposed to a cable tunnel scheme). Twelve boreholes were drilled along Route 1 between Pointe Amour and Yankee Point. The results of this drilling program show that the overburden consists of thin deposits of sand and gravel in places overlying shallow deposits of dense till. Along the route from Pointe Amour to Yankee Point, the average thickness of overburden is 1.8metres. Including the till, the depth to the interbedded limestone and shale bedrock, is 2.5 to 3 metres. Sandstone was encountered only over a distance of 2.1 kilometres near the Newfoundland side. The amount of shale within the formation was less than had been expected from earlier assessments, indicating that the bedrock is of a relatively high strength. The work also indicated that a number of ledges and slopes were evident that would require remedial blasting for submarine cable embedment. Ledges were defined as any rock face with a slope greater than 20 per cent. Along the cable route (essentially the same as the proposed tunnel route), the number of such ridges identified was six, and the average and maximum height was 3.2 and 6.0 metres. The length of rock trenching to achieve an objective of a depth of 85 metres below mean sea level (to accommodate iceberg scour) was 11.9 kilometres (of a total distance of 17.8 kilometres), and the length of overburden trenching was the remaining 5.9 kilometres.

On shore on the Labrador side, the overburden has an estimated thickness of 1 to 3 metres and is composed of glacial till and raised beach deposits underlying a thin layer of peat and grassland. On the Island of Newfoundland side, in the vicinity of the tunnel access, the overburden consists of sand and gravel of up to 2.5 metres in thickness that is overlain by peat. The soil, which contains rock fragments ranging in size from a few millimeters to cobbles and boulders, overlies sedimentary rock strata which is approximately 460 metres deep.

Geological Faulting and Water Ingress Considerations

As noted previously, the bedrock geology of the Strait has been inferred from seismic surveys and the drilling results of the shore-based program. It was also noted that, according to seismic interpretation, there are 14 faults in the structure. A further discussion of these faults and the potential for water ingress in a tunnel concept is presented in a report by SNC-Lavalin (1980) and that discussion is largely repeated here.

The faults are high angle normal (gravity) or reverse faults and their interpreted locations were shown on the profile of Figure 3.3. These faults have been responsible for upthrusting and downfaulting of individual large blocks or rock along them. Variation in vertical offsets range from a possible 75 metres in the vicinity of the Labrador trench to a possible 45 metres at the Newfoundland shore. In the vicinity of the Central Bank, vertical offsets along the faults appear not to exceed 15 metres. The faults have been interpreted as extending continuously with depth from the bedrock surface at the floor of the Strait through the sedimentary rock strata thence deep into the underlying Precambrian.

Geological mapping of the faults has indicated that those located in limestone may be associated with a zone of brecciation and fracturing up to 15 metre width. Faults in sandstone are generally not associated with brecciated zones although some brecciation is present at the bottom of the Hawke Bay sandstone a few metres above the Forteau contact. It is probable that although the depth of faulting cannot be estimated accurately from offshore seismic data, it can be assumed that some major faults have penetrated beyond the Cambrian sedimentary rocks into the Precambrian metamorphic complex. The depth of these faults is not established and it can only be concluded that some, if not all, will intersect a tunnelled crossing of the Strait.

It is also assumed that in many cases the faults in the Palaeozoic rocks have occurred along zones of weakness in the Precambrian rocks caused by existing faults of Precambrian age. Interconnections between faults of different ages are possible.

The amount of water, if any, in these fault zones and the rate at which it would flow should they be intersected by the tunnel, cannot be estimated from seismic work. Surface observations of faults indicate that brecciated and fractured zones are frequent on both sides of the Strait. In some cases zones of brecciation and fractures in the faults are recemented with secondary calcite. Such zones should be regarded as impervious. The water well drilling on the Labrador side, located approximately 240 metres west of the shaft site for the cable tunnel concept and hydrogeological studies on the Newfoundland side strongly indicate that aquifers of significant size occur only in fault or fracture zones. The water wells drilled through such zones have been productive with an estimated capacity of over 45 litres per minute while those drilled away from the fault zones were dry. This indicates that some fault zones located under the Strait might be water bearing. The risk of further movement along existing fault planes or even the occurrence of new faults is considered to be low for the Strait of Belle Isle. However, earthquakes with magnitudes of 3 to 4 on the Richter scale have occurred within 160 to 240 kilometres of the tunnel area.

The selection of the invert elevation of the cable tunnel was made so as to ensure that it would be located in the Precambrian basement rocks in order to reduce the risk of excessive water inflows into the essentially unlined drill and blast tunnel. It was assessed that sedimentary rock strata could prove to be water bearing, much more so than the underlying gneiss. Inflows into the tunnel located in gneiss were considered to be restricted to those directed along existing faulting.

In the cable tunnel cable concept, the minimum amount of granite roof cover was fixed at about 46 metres so that, with consideration of the interpretive geological profile under the Strait, 46 metres would then exist below the lowest sedimentary rock strata on the Newfoundland side. This 46 metres roof thickness measurement was apparently determined from the possible vertical offset along faulting at Flowers Cove. If such vertical offset were more than 46 metres, sedimentary rock strata might then intersect the tunnel horizon. Insofar as the tunnel invert would be located below the lowest elevation of the southerly dipping sedimentary strata, the tunnel would be located in gneiss for the remainder of the distance across the Strait.

It was considered that the individual proportions of schist, biotite gneiss, feldspar gneiss and granitic rocks cannot be estimated at this time. The foliation in the granite gneiss varies from 20° to 40° in the Labrador shaft to 40° to 60° in the Newfoundland shaft. It is possible that the content of schistose rock probably relates to the mica content in the rock and so may not be significantly large. Wherever the granitic rocks have been observed on shore and in the boreholes, the rock is reasonably fresh and unweathered. Its condition in the vicinity of faults is not known.

The 1980 studies concluded that a substantial increase in the amount of geotechnical detail would be required through additional borings.

Boreholes would be located so as to confirm the predicted amount of vertical displacement of strata produced as a result of faulting. In addition, it was considered to be of particular importance to investigate the condition of the rock at the upper and lower contacts of the Forteau Formation and at the top of the Precambrian granite gneiss on both sides of the Strait. Studies of these areas have indicated occurrence of fractures, water inflows, drilling water losses, gypsum, fault gouge and areas of soft rock as indicated on the borehole logs. In all borehole investigations on both sides of the Strait, permeability testing of the rock in situ was suggested. Two inclined boreholes were recommended on the Labrador side to intersect and partially determine the condition of the faults underlying the north side of the Labrador trench that were interpreted to extend into the cable tunnel horizon.

In addition, it was suggested that a program be conducted from the cable tunnel during the construction period by means of investigative boreholes in advance of each tunnel heading. This procedure would allow pre-grouting considerations and final design criteria to be assessed immediately in advance of shaft and tunnel construction.

3.6 Design Criteria and Considerations

Environmental Design Criteria

The design criteria associated with the physical environmental parameters of the study area may be summarized as follows from the above discussion.

Climate

Minimum design air temperature	-30° C

Maximum hourly wind speed	97 kilometres per hour
Maximum gust wind speed	148 kilometres per hour
Design hourly wind pressure	1.01 kiloPascal
Atmospheric Icing	11.5 cenimetres with 115 kilometres per hour wind gust
Ground snow loading	4.2 kiloPascal
Freezing Degree-Days	1323 ° C-days

Oceanography

Currents	
-at 15 metres depth	3.6 metres per second
-at 50 metres depth	2.5 metres per second
Maximum Wave Height	10 metres
-100 year return period	

Sea Ice

Uniform ice floe thickness	0.6 metres
Ice compressive strength (uniform ice)	2 megaPascal

Icebergs

Mass	1 million tonnes
Speed	1 metres per second
Ice strength	5 megaPascal
Scour depth (1000 year return period)	5.5 metres

3.7 Capacity and Dimensional Requirements for the Fixed Link

Projected traffic demand, emergency egress and ventilation are the principal factors in determining the spatial requirements of a tunnel. Each of these items is addressed below for road and rail configurations. Consideration is also given to accommodating HVDC cables in the tunnel.

Traffic volumes and mode of transit

As an early activity during the study it was necessary to carry out a scoping level assessment of the traffic that a fixed link across the Strait of Belle Isle would attract in order to determine the capacity required for the facility. This assessment was made to establish the size of the structures in terms of the number of traffic lanes or the number of tracks. A preliminary forecast was made of traffic volume generated 30 years after construction. Traffic could develop from a number of sources as follows:

- Diversion from existing established routes
- New developments to attract automobile tourism and induced demand
- New economic developments to attract long term commercial vehicle traffic
- Major projects that may generate elevated demand for defined periods

The traffic that presently crosses on the existing ferry service was assumed to transfer totally to the new fixed link after the closure of that service. Further, half of the present traffic using the Gulf ferries was also assumed to divert to this crossing. This was considered to be an optimistic assumption but appropriate for an initial sizing assessment. Similarly, a generous annual traffic growth of 2.5% was assumed.

The resulting traffic volumes in equivalent Passenger Car Units (PCU) are shown in Table 3.1. Cars are considered as one PCU per vehicle and commercial vehicles are considered as three PCU per vehicle.

Table 3.1 - Preliminary Traffic Volume Summary

Description	Base Volume at Year 1		Sizing Volume (PCU) at Year 30
	Existing Peak per day	Diversion Peak per day	Total Daily Volume
Passenger Cars	160	315	2,042
Commercial PCU	22	350	1,621
Total PCU	182	665	3,642

Highway lane capacity is normally assessed in terms of peak hour volume that can safely operate in fluid conditions. For a two-lane undivided highway in Canada, the rule-of-thumb is 1,200 PCU per hour per direction.

Since the route under consideration is rural and remote, peak periods are spread over a number of hours, say 5 hours each day. During this time, 50% of the average daily volume could be accommodated and the balance of the demand would be spread over off-peak periods. Based on the above estimates of 3,642 PCU per day, the peak design hour should accommodate 364 PCU in aggregate for both directions or 182 PCU per hour per direction. This is well below the rule-of-thumb for two-lane undivided highways.

Since the expected traffic is significantly less than the capacity of a two-lane highway it is appropriate to investigate lower capacity options. An alternative to two-lanes is a managed single lane operation with periodic single direction operation. However, for the causeway or bridge alternative means of providing a fixed link, the incremental cost differential between providing a two lane crossing compared with a single lane is so small that it would not be economically feasible to construct such a facility at less than a two-lane configuration. Conversely, for the tunnelled options, the cost increment associated with providing two lanes compared with one lane is very large and there is significant justification to minimize the area of the tunnel cross sections and to select a single-lane configeratoin.

A single lane (with an emergency lane) could operate alternately in opposite directions in a controlled environment. An operating speed of 50 kilometres per hour would imply under 30 minutes to enter, traverse and exit the crossing. If the window of operation was 30 minutes at the entrance, with 30 minutes to clear the tunnel then after one hour the direction of operation could change after the last vehicle clears the portal. The traffic would then operate in the opposite direction for a period of 30 minutes plus 30 minutes clearing time. Therefore for 25% per cent of the time, traffic could enter in one direction, and 25% of the time could enter in the opposite direction. This would provide a capacity of 300 PCU (1200 x 25%) per hour in each direction. An alternating-direction single-lane tunnel therefore appears to be a feasible alternative based on capacity considerations.

Based on the above, a traveller would experience a total crossing time, including waiting time, of between 30 and 90 minutes.

Another option is an electric rail shuttle, single-track operation. This could be made to operate at a higher speed than might be safe for road vehicles, (design speed assumed at 100 kilometres per hour) and it could be designed for different capacities per train. For example, in order to provide sufficient capacity for 250 vehicles per hour per direction, there would have to be two trips, each with 125 vehicles per direction. A 21-car train with six vehicles per car, and seating capacity for passengers (likely remaining in their vehicles) would accomplish this. This option is close to the upper limit of projected capacity requirements, however.

The rail shuttle option assumes a 12 hour operating day during which trains would leave Newfoundland at 30 minute intervals and would leave Labrador at 30 minute intervals. Train loading and unloading allowances are between 5 and 15 minutes depending on time of traveller arrival. The trip time has been calculated at 15 minutes. Based on this operating scenario, a traveller would experience a total crossing time including waiting, loading and unloading, of between 25 minutes and 60 minutes.

Therefore the three options to consider for costing and preliminary design are; for the bridge and causeway alternatives, (i) two lane road, and for the tunnelled options, (ii) managed one lane configuration for motor vehicle operations, and (iii) electric train shuttle operation for passenger cars and commercial vehicles with capacity for simultaneous load/discharge of at least two 21-car train sets.

Road Tunnel

Clearances

The traffic analysis discussed above indicated that a single-lane tunnel operated in a cycle with flow in one direction followed by flow in the opposite direction will satisfy the projected traffic demands. There are no specific vertical and lateral clearance standards for single-lane uni-directional tunnels, and in North America, general standards for clearances in tunnels are not well established. The following documents were therefore referenced in order to obtain guidance on appropriate clearance standards for the highway tunnel option:

- PIARC: World Road Association "Cross Section Geometry in Unidirectional Road Tunnels"
- AASHTO Standard Specification for Bridges, Section 2.5 Highway Clearance for T

Using the guidelines within these documents and HMM's experience on similar highway tunnel projects, the following parameters were adopted for development of highway tunnel cross-sections:

• Maximum truck width	2.6 metres
• Maximum truck height	4.2 metres
• Lane width	3.75 metres
• Vertical clearance from vehicle running surface	4.65 metres
• Off-roadway distance	0.75 metres + shoulder width
• Shoulder width	1.25 metres

This configuration permits vehicles to pass a truck or other vehicle that has broken down within the tunnel as shown in Figure 3.4.

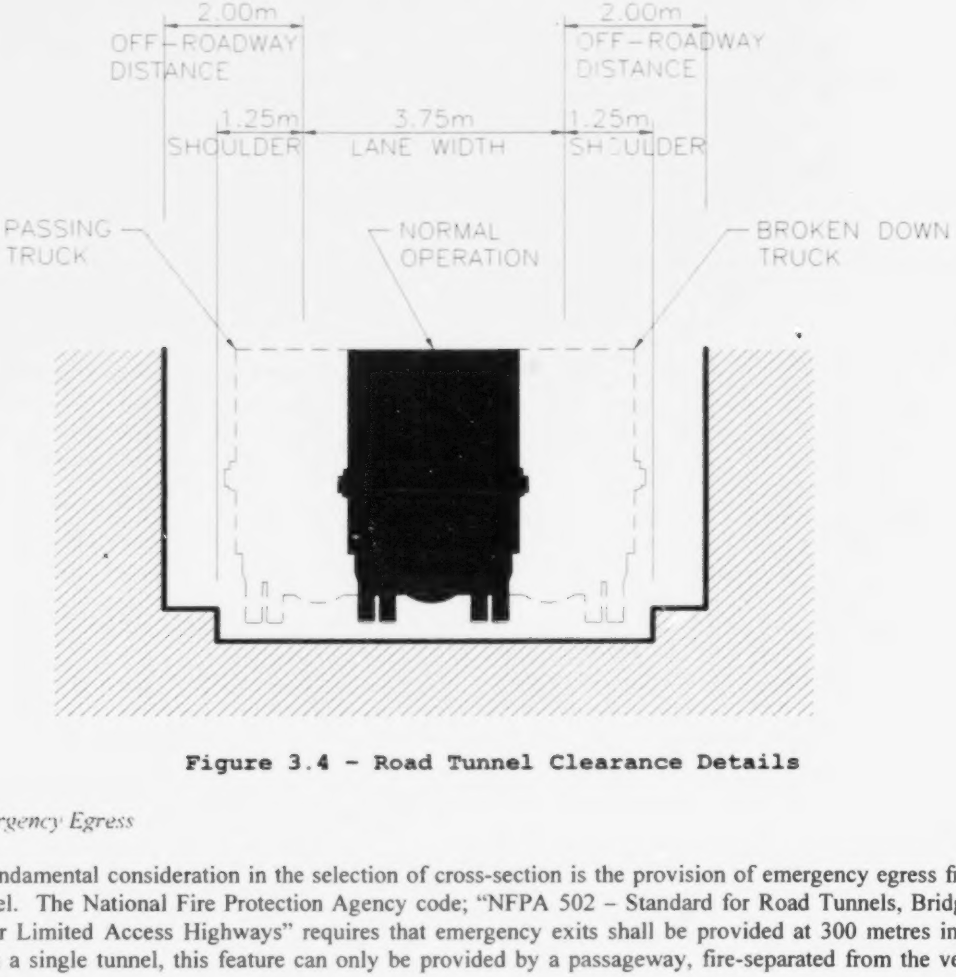
2.00m
OFF-ROADWAY DISTANCE
2.00m
OFF-ROADWAY DISTANCE
1.25m
SHOULDER
3.75m
LANE WIDTH
1.25m
SHOULDER
PASSING TRUCK
NORMAL OPERATION
BROKEN DOWN TRUCK

Figure 3.4 - Road Tunnel Clearance Details

Emergency Egress

A fundamental consideration in the selection of cross-section is the provision of emergency egress from the tunnel. The National Fire Protection Agency code; "NFPA 502 – Standard for Road Tunnels, Bridges and Other Limited Access Highways" requires that emergency exits shall be provided at 300 metres intervals. With a single tunnel, this feature can only be provided by a passageway, fire-separated from the vehicular space.

Ventilation

Spatial allowances for ventilation in road tunnels can have a significant impact on the tunnel dimensions. There are two principal systems for ventilating road tunnels as follows:

- Longitudinal ventilation – this system of ventilation uses jet fans spaced along the length of the tunnel to drive a continuous flow of fresh air through the tunnel. The system is only suited to short road tunnels as required velocities to overcome frictional resistance become very high in longer tunnels. The system can be used for longer electric train rail tunnels.

- Transverse ventilation – this system of ventilation passes fresh air transversely across the tunnel at discrete locations throughout its length with separate supply and exhaust ducts being used for supply of fresh air and removal of polluted air. Such a system is generally adopted for long road tunnels.

A preliminary analysis of the ventilation requirements was undertaken assuming a 20.5 kilometre road tunnel with six percent grades and using the projected traffic from the preliminary traffic demand analysis undertaken during Phase 1 of the study. The study also recognized the planned operation of the tunnel as a single-lane facility with traffic operating periodically in one direction and then in the other direction. This analysis indicated that the optimum method of ventilating the road tunnel is likely to be a combination of longitudinal and transverse ventilation with the tunnel divided into five separate ventilation zones as shown in Figure 3.5 below. This method would have jet fans installed within the tunnel at intervals to encourage longitudinal flow. However, these jet fans alone would not provide enough ventilation for a tunnel of this length. Therefore, additional fresh air would be introduced and stale air removed at four discrete points along the length of the tunnel. These four points divide the tunnel into five ventilation zones as shown in Figure 3.5. To deliver and remove air from the discrete ventilation points large dimension conduits are required. For Zones 1 and 5 these requirements are doubled, as parallel conduits are needed to reach the inner ventilation points. In the conceptual configuration, as Zones 1 and 5 are largely under land, it may be possible to deliver this additional ventilation via shafts and parallel tunnels.

With this scheme, there would be an advantage to provide a variable cross-section tunnel with the spatial arrangement adjusted to the requirements of the various zones. This is possible for drill-and-blast excavation but would likely not be practicable for TBM driven tunnels since a change in TBM size would be required.

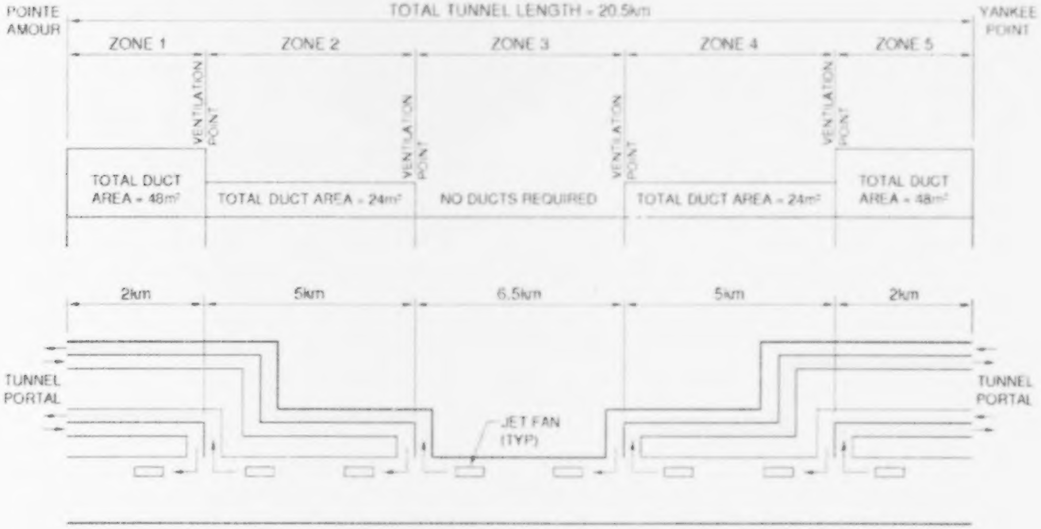
POINTE AMOUR
TOTAL TUNNEL LENGTH = 20.5km
YANKEE POINT
ZONE 1
ZONE 2
ZONE 3
ZONE 4
ZONE 5
VENTILATION POINT
VENTILATION POINT
VENTILATION POINT
VENTILATION POINT
TOTAL DUCT AREA = 48m²
TOTAL DUCT AREA = 24m²
NO DUCTS REQUIRED
TOTAL DUCT AREA = 24m²
TOTAL DUCT AREA = 48m²
2km
5km
6.5km
5km
2km
TUNNEL PORTAL
TUNNEL PORTAL
JET FAN (TYP)

Figure 3.5 - Road Tunnel Ventilation Duct Requirements

Consideration was also given to the use of mechanical air scrubbers as a means of providing a constant supply of clean air within tunnel. This concept has been used in the Laerdal Tunnel in Norway, in one or two tunnels in Japan, and is under consideration for tunnels in Australia. Research on these applications revealed that the technology is in its infancy and that there have been problems with maintaining the scrubbers and with their high energy usage. In the Leardal tunnel, the air cleaning facility has not really been tested since the traffic and related pollutant levels have not required their use. One particular problem, yet to be resolved, is that the scrubbers only remove particulate matter and do not address other chemical pollutants. These are presently removed by passing tunnel air over beds of activated charcoal. These beds require large surface areas that are difficult to accommodate underground.

Therefore, for the purposes of this study, in-tunnel cleaning of the air has been considered to be unreliable and has not been considered further. This is an area of technology that may be more developed when this project is progressed further and should not be discounted completely if the road tunnel scheme were pursued.

Rail Tunnel

Clearances

Tunnel size requirements are reasonably well defined for railway tunnels, and for the purposes of this study it has been assumed that a 'shuttle' railcar similar to that used for the Channel Tunnel and associated tunnel clearance envelope are appropriate. Figure 3.6 shows the required dynamic clearance envelope for such a vehicle.

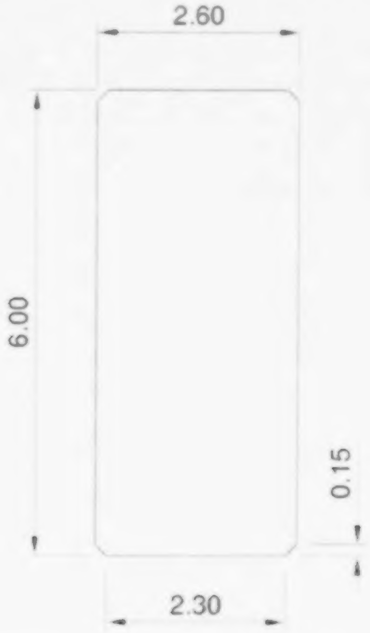

Figure 3.6 - Dynamic Clearance Envelope for Shuttle Railcar

Emergency Egress

Although tunnel fires and similar emergencies are less likely to occur in railway tunnels, it is essential to provide a means of emergency escape. A continuous escape passage for the full length of the tunnel has therefore been provided. The National Fire Protection Agency code, NFPA 130, requires that emergency exits be provided at 240m intervals.

Ventilation

Preliminary analysis of the ventilation requirements for the railway tunnel option was based on the use of electric trains and 1.5 percent grades on either side of the Strait. A 27 kilometres long railway tunnel can be adequately ventilated using longitudinal ventilation with jet fans distributed along the tunnel.

HVDC Cabling Requirements

The proposed fixed link could accommodate the installation of High Voltage Direct Current (HVDC) power cables, a component of the proposed transmission link between the Island of Newfoundland and the proposed hydroelectric developments on the lower Churchill River in Labrador. The expected basic parameters of the transmission system as provided by Newfoundland and Labrador Hydro are as outlined below:

• Power transfer capacity of the link	800 MW.
• Proposed circuit voltage	+/-400 kV
• Minimum nominal cable current capacity	1000 Amperes
• Nominal cable power capacity per cable	400 MW
• Number of cables proposed in service	2, one positive, one negative
• Number of spare cables	1, connectable positive or negative.
• Circuit length, Gull Island to Soldiers Pond	1100 kilometres

The aerial (overland) component of the circuit is not the subject of this discussion, but for interest sake it may be assumed that each pole of the circuit, positive and negative, will be composed of 2 conductors with roughly 2000 Amperes total capacity to allow for possible temporary overload operation of 800 MW per pole. The conductors would probably be ACSR of a size range between 1033 and 1590 kCMil.

Each cable in the tunnel is expected to be capable of carrying 1000 Amperes, on a steady state basis, with temporary overload capability for between 10 to 20 minutes of 2000 Amperes. It is expected the cable would thus be oversized to some extent to allow for this overload capability; a rating of 1150 Amperes was proposed in previous design exercises. There are a limited number of different cable types that could be used for the cable circuit, as listed below:

- High-pressure pipe-type cable, either gas or oil-pressurized
- Gas pressurized cable
- Low-pressure oil-filled cable
- Solid dielectric cable

These various cable types have been reviewed in detail in the engineering studies referred to previously. The high-pressure alternative was not favoured on the basis of high cost, and the lack of applicability of this cable type to dc cable circuits, particularly those in protected environments such as tunnels. The gas-pressurized paper-impregnated cable type has existed for many decades, and experience has generally been favorable; however, its use has been limited. As there is very little of this type of cable being manufactured at this time, and there are concerns with its use in cases where significant elevation changes occur, due to cable impregnation compound migration, this cable type was also not favored. The cable type that was recommended previously is the low-pressure oil-filled type of cable. This cable has been in use for many decades and it is still the only cable that is normally considered for ac circuits at the 500-kV voltage level. The use of this type of cable is of concern when proposed for use over routes that have a significant variance in elevation. There are, however, existing well-proven design practices that allow a solution to these problems. For instance, the Churchill Falls Powerhouse has some thirty-three 230-kV low-pressure oil-filled cables with approximately 300 metres in elevation difference from one end to the other, and these have proven satisfactory in operation for more than 30 years. Thus, this cable type can be considered suitable for use in the current application.

The fourth type of cable, solid dielectric power cable, meaning cable with cross linked polyethylene insulation was not considered suitable during the original engineering study because its reliability wasn't considered proven at the proposed voltage level. In the intervening years, solid dielectric cable designs have been the subject of much improvement; and they have now come into common usage at the 230-kV ac level, and they are also being used fairly routinely at the 345-kV ac level. The cable in the tunnel, operating at +/-400-kV dc, would be subject to voltage stresses slightly above standard 230-kV ac levels; however, solid dielectric cables should be considered suitable for use in the fixed link tunnel at this time. As this type of cable has no liquid in its composition, the major problem experienced with oil-filled cables, namely excess pressures inside the cable due to changes in elevation, would not exist. One benefit of using solid dielectric cables is that the elaborate fire prevention and extinguishing systems needed with oil-filled cables are not essential, although some fire detection measures are required, because cross linked polyethylene does burn, and when doing so it gives off noxious gases.

A nominal conductor size of 800 mm^2 copper, or 1150 mm^2 aluminum, should be adequate to provide a continuous nominal current rating of 1150 Amperes for both the low-pressure oil-filled cable type, or the solid dielectric cable type. Copper has been the more commonly used conductor material in the past; but aluminum is becoming used more often, due to its lower cost and lighter weight. Copper conductor, oil filled cables, would have an outside diameter of approximately 100 mm, with the aluminum conductor alternative being slightly larger.

There are a number of different ways in which the cables can be supported within the tunnel. The original design study assumed the cables would be laid in open concrete trenches, presumably located to one side of the tunnel. Two other ways of installing the cables would be to either fix them to the side walls or ceiling of the tunnel using appropriate supports. Hardwood clamps dowelled into the walls or ceiling of the tunnel have proven suitable in previous installations; or the cables could be supported as they traditionally are in underground mines, by suspension from strands supported from dowels in the walls or ceiling of the tunnel.

The space envelope required in which to accommodate HVDC cables would be in the order of 1 metres along the face of the tunnel by 300 mm deep. The space needed for splicing would be larger than this envelope. The splices should be staggered so that they are not all in the same longitudinal space. When finished, a splice itself, along with its two companion cables, would not require an area significantly larger than the envelope described above. In order to make a splice, a minimum working space approximately 6 metres long by 2 metres wide would be required, with an appropriate height allowance for working room. Once the splices are made, they should be permanent and need no further attention; but to cater to the possibility of a splice failure, provision would have to be made during the construction phase of the project to replace one or more splices if needed. Replacement of a splice could take as long as a week. Given the size of the cable to be installed, a reel length of between 800 to 1000 metres may be assumed. During the actual execution of the work, every reasonable attempt should be made to maximize the reel length employed so as to ensure the minimum number of splices, which will be the most failure-prone portion of the circuit, as well as the most time-consuming portion of the installation exercise. Enough spare splicing materials should be kept near the site to ensure a replacement splice can be installed if, and when required, without a significant wait to obtain suitable materials.

4 ASSESSMENT OF ALTERNATIVE FIXED LINK CONCEPTS

Three basic link concepts were studied; these are, a bridge, a causeway with bridges, and a tunnel. In the case of a tunnel, the options were further divided into bored, drill and blast, and immersed tube methods of construction. Both road and rail modes were considered for the tunnel option. Each of these concepts is addressed in this section of the report.

For each of these concepts, the route across the Strait was taken as that between Pointe Amour and Yankee Point, which is the shortest distance at 18 kilometres. Water depths are actually less in an area about 20 kilometres east of this line; however, the distance across the Strait in this latter location is 27 kilometres or 50 per cent greater. This would be of most importance to a bridge or causeway concept in terms of cost reduction with lesser impact on a tunnel concept (hydrostatic pressures in the tunnel would be reduced in shallower water); however, a preliminary assessment suggests that the longer distance would more than offset any savings in costs due to smaller water depths. Therefore, for this pre-feasibility level analysis, the shorter route was used for all concepts.

4.1 Bridge

A bridge crossing of the Strait presents very large risks, the key engineering, construction, and operating challenges being:

unprecedented design and construction conditions for a bridge; as far as is known, no bridge has ever been constructed in an iceberg zone

the need for deep foundations in a deep-sea channel affected by large currents

difficult weather, sea and ice conditions with considerable risk to construction and the potential for delaying the construction schedule.

the risk of closure during operation in winter for significant periods due to weather conditions. Weather conditions will also make maintenance difficult; hence, any design must minimize maintenance requirements.

For a crossing of this length across a navigation channel, a combination of multiple medium spans (100 + m) and long span cable supported bridges would typically be required as this combination would reduce the number of very expensive foundations. However, in this particular case, since all foundations would have to be protected against iceberg impact, it would be more appropriate to consider a series of long spans between artificial islands or otherwise protected foundations to minimize the very extensive protection works.

Because of the water depths in the Strait and the need to minimize the exposure of structures to iceberg loadings, it is clear that the greatest possible spans and, hence, a suspension bridge would be used.

The suspension bridge concept is shown in Figure 4.1. The arrangement has seven individual back-to-back suspension bridges, each 2 kilometres in length. Such an arrangement requires 8 intermediate piers, and results in a lateral clearance of 2 kilometres between piers. There is a shore anchor on the Labrador side and a viaduct to accommodate the elevation difference on the Newfoundland side. A 50-metre clearance is used between the bridge deck and sea level to accommodate vessels and icebergs. Such a clearance should also be sufficient to prevent significant amounts of sea spray from contacting the deck. Components would have to be designed for atmospheric icing, however.

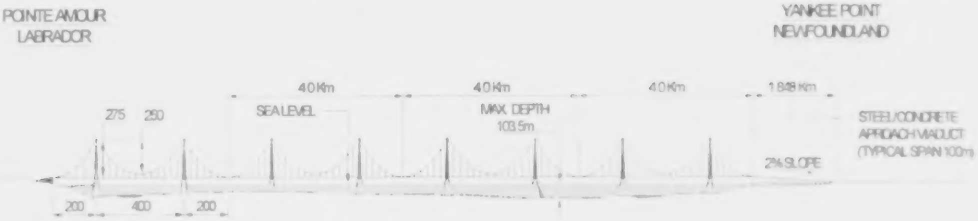

Figure 4.1 Suspension Bridge Concept

The foundations would be precast concrete caissons typically constructed in a dry dock and then towed to site and sunk onto specially prepared areas of the seabed. Preparation normally involves drill and blast and dredging to create a "notch" for locating the pier caisson. Concrete infilling and grouting are then undertaken to complete the foundation. The piers would be constructed by cast-in-place concrete techniques, likely using slipforming. Suspension cables would be spun using methodologies that have become normal for suspension bridges. The deck sections would be prefabricated, brought to site and hoisted to position and attached to the hanger cables. The anchors at each end of the multi-span bridges would be very substantial structures.

All of the bridge piers would have to be protected by berms in order to withstand impact forces from icebergs. These berms would also have to be protected by armour stone in the wave zone. The size of stone for wave protection is generally well understood; for the design wave in the study area, a stone weight of 15 to 20 tonnes would be needed. Two layers of such stone would be used over a total height of 20 metres (10 metres above and below mean sea level); the stone would rest on a ledge created in the rockfill at a depth of 10 meters. Below this depth, the berm would be protected by stone of a nominal 1 metre in diameter (1.4 tonnes) to assist in absorbing iceberg loads. Assuming berm slopes of 1.8 horizontal to 1 vertical and a top diameter of 15 metres, the total volume for each berm would be approximately 4.7 million m^3. Such berms would further narrow the 2 kilometres wide shipping channel as the toe of the berm would extend about 200 metres from the pier. The effect of the piers on the current regime is not known but would require study if the concept were deemed feasible.

The cost of the pier protection works was based on broad unit costs for quarrying, transporting and placing rockfill and armour stone. For general angular rockfill, a unit cost of \$50 per m^3 was used for placement at sea; for the larger armour stone, \$100 per m^3 and \$200 per m^3 were used for the 1.4 tonne and 15 tonne stone respectively. There is no known precedence for placing such large armour stone at sea, and it is quite possible that this unit cost is low. (See a recent survey of armour stone pricing in Newfoundland by Meyer Industrial Mineral Consultants.) In any event, the much larger quantities of smaller rockfill mask the cost of the armour in the costing exercise. Based on these unit costs, the total cost of the protection works for each pier is approximately \$260 million. For eight piers, the cost would be \$2.08 billion.

For bridge foundations and superstructure components, unit costs were developed from the experience of HMM on other bridge projects, with appropriate weighting for this application. The total cost of the bridge concept, including protection works, would then be \$4.23 billion. This assumes 25% construction contingency, \$15 million pre-design costs, and 17% applied to the overall estimate for design, construction management, and owner's costs.

Figure 4.2 details the highway cross-section used for the bridge and bridge / causeway options. This cross-section assumes that the bridge would be constructed as a suspension bridge, and provides two 3.75 metres wide lanes with 1.25 metres wide shoulders on a 10 metres wide bridge deck.

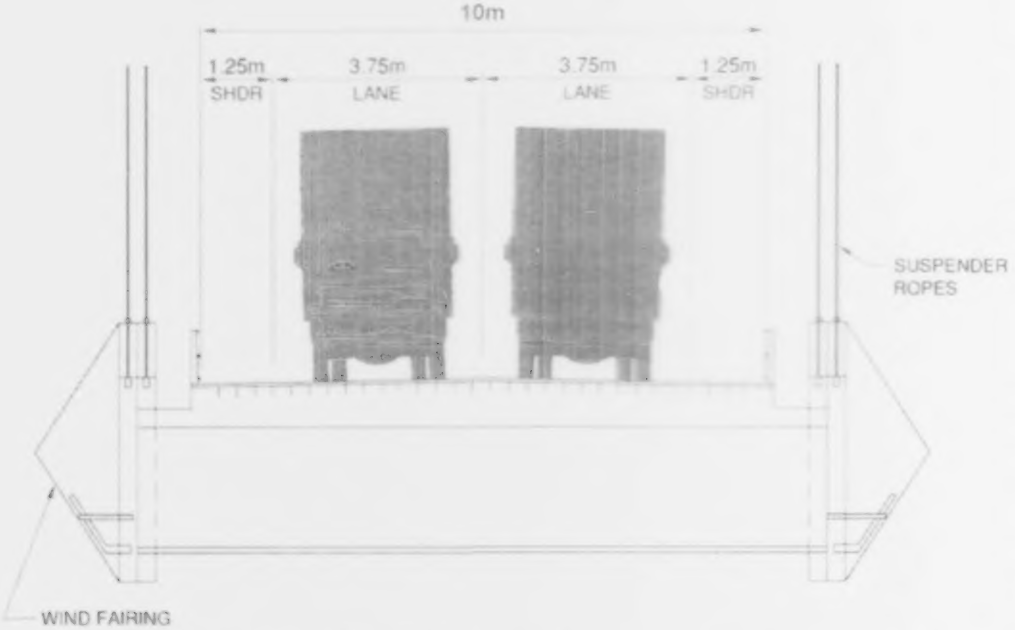

Figure 4.2 - Highway Bridge Cross Section

4.2 Causeway

A causeway across the Strait of Belle Isle would be an ambitious undertaking, although with possibly lower risk from a design and construction point of view than is the case with an all bridge concept. While a causeway would still need one or more bridges, it could cope more easily with ice and icebergs and the bridge piers could be integrated into the causeway for protection. Foundations and anchoring for the bridges would still be very challenging; however, the number of foundations would be less. Overall, although working in the same hostile environment, the risk to construction schedule would likely be less with this concept. Maintenance risk should also be less since there would be fewer bridge components to maintain. However, an obvious major environmental risk is the possible effects that such a structure could have on the current regime in the area, short term weather conditions and longer term climate. This would be a major subject of study if such a concept were to be addressed beyond this pre-feasibility level. Any further study would also need to identify sources for the massive amount of rock required for the construction.

A causeway would be designed with openings to accommodate shipping and currents. For the purposes of this study, it has been assumed that two openings would be needed in the causeway as shown in Figure 4.3 and that these would be located at the position of the shipping lanes shown on the marine chart for the area.

The concept proposed here involves construction of rock fill berms from each shoreline, with two suspension bridges spanning the shipping channels to an inner berm that would be constructed using a marine plant.

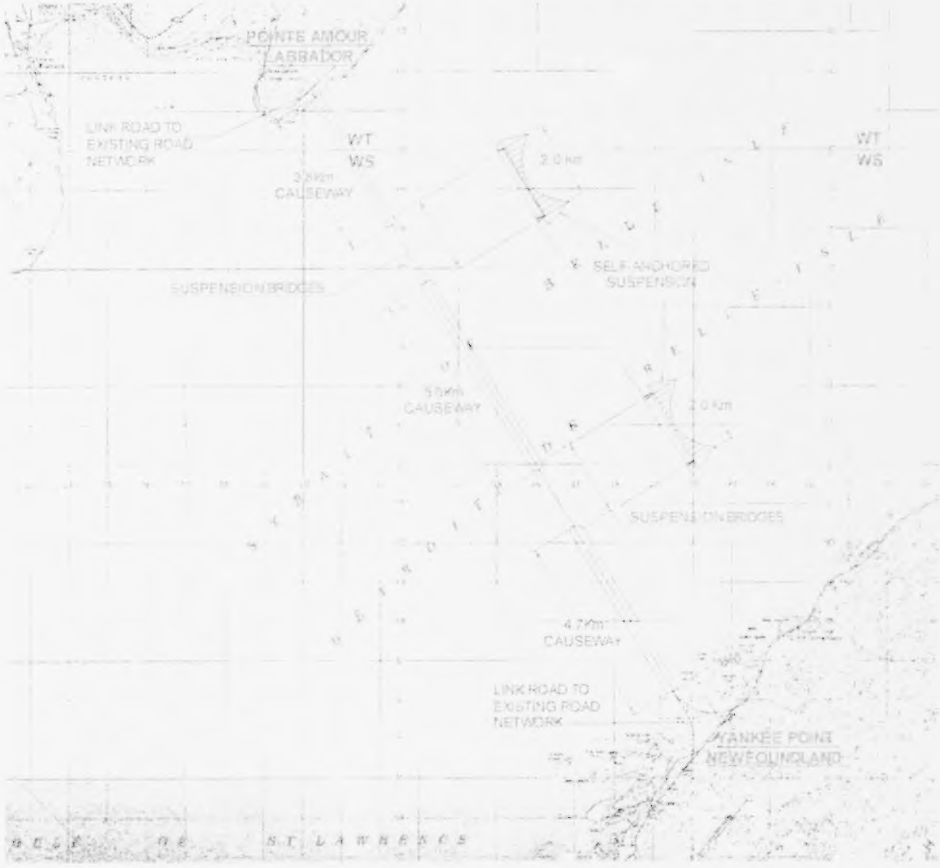
POINTE AMOUR
LABRADOR
LINK ROAD TO
EXISTING ROAD
NETWORK
WT
WS
3.8Km
CAUSEWAY
2.0 km
WT
WS
SELF ANCHORED
SUSPENSION
SUSPENSION BRIDGES
5.6Km
CAUSEWAY
2.0 Km
SUSPENSION BRIDGES
4.7Km
CAUSEWAY
LINK ROAD TO
EXISTING ROAD
NETWORK
YANKEE POINT
NEWFOUNDLAND
GULF OF ST. LAWRENCE

Figure 4.3 Causeway Arrangement

Assuming use of 2 kilometres long main span suspension bridges results in a 3.8 kilometres long berm on the Labrador side, 5.6 kilometres in the middle portion, and 4.7 kilometres on the Newfoundland side. The bridge span is less than the width of the shipping channels shown on the chart (and the toe of the causeway would also encroach into the shipping lane) but is a reasonable approach to determine concept configuration and costs. The causeway sections on either side of the Strait would be constructed from the shore by end dumping, while the mid section would have to be placed by ships or barges at considerably higher cost. The concept also features a 670 metres long viaduct section on 6% grades at both ends of each bridge in order to provide the change of elevation between suspension bridge and causeway sections. The viaduct substructures would be located above the causeway in these transition zones, with friction or end bearing piles penetrating the causeway to form the foundations to the viaduct structures.

During the construction, a method of handling encroaching icebergs would have to be devised for certain of the operations; this may be a matter of implementing an iceberg management program to monitor and tow icebergs away from the construction area. The oil industry operators routinely do this on the Grand Banks, although currents in the latter area may not be as much of a concern for towing as they could be in the Strait of Belle Isle. Once completed, the berms would arrest the motion of icebergs and prevent any contact with the bridge piers. The movement of water through the bridge openings may result in increased iceberg drift through these areas and possibly a greater incidence of icebergs south of the link. This is another issue that would require study if the concept were advanced beyond the present pre-feasibility stage.

The causeway composition as shown on Figure 4.4 would be similar to the protective berms for the piers in the bridge concept - rockfill with larger armour stone for wave protection to a depth of 10 metres and smaller armour stone to the seabed. Based on a road top surface 15 metres wide and 10 metres above mean sea level, and a side slope on the rockfill of 1.8 to 1, the total volume of rockfill would be 119 million m^3 for the two shore sections and 61 million m^3 for the mid section for a total volume of 180 million m^3. Assuming rock can be quarried, transported and end-dumped for $15/$m^3$ (in place), the cost of the two sections from shore would be in the order of $1.78 billion. The cost of a marine dumping operation is assumed to be $50 per m^3 so that for the mid-section, the cost of rockfill placement would be $3.56 billion. The cost for the rockfill for the three berms over the 14 kilometres would then be $5.59 billion.

The volume of large armour stone, based on two layers of 15 tonne stone, would be 1.6 million m^3 and the volume of smaller armour stone would be 3.3 million m^3. Quarrying, transporting, and placing the armour stone, because of its size, would be considerably more demanding and costly than the rockfill. An average cost of $100/$m^3$ is assumed here for the larger stone for the two nearshore sections and $200/$m^3$ for the mid-section. The smaller armour stone is assumed to cost $50/$m^3$ for the two shore sections and $100/$m^3$ for the mid-section. The cost of placing two layers of both sizes of stone would be $572 million. The total cost of rockfill and armour for the three causeway sections would then be approximately $6.16 billion.

Including the costs of the suspension bridges and approach viaducts, the total cost of the causeway option would be approximately $10.1 billion. This assumes 25% construction contingency, $15 million for planning and preliminary design, and 17% applied to the overall estimate for detailed design, construction management and owner's costs.

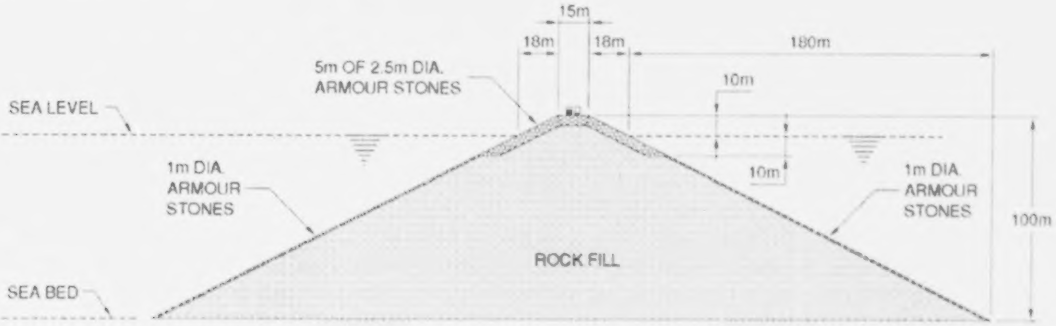

Figure 4.4 - Causeway Cross-Section

4.3 Tunnels

Most of the risk factors associated with a surface crossing of the Strait of Belle Isle are eliminated with a tunnel that is constructed below the seabed. For an immersed tube tunnel (ITT), the risk of iceberg impact still exists if the depth of immersion is not sufficient. However, the tunnel elements would have to be protected either by being buried below the depth of iceberg scour or by having sufficient protection to absorb the energy of an iceberg if elements are laid on the seabed or at shallow immersion depths.

One of the primary risks associated with drill-and-blast or bored tunnels relates to the potential for water ingress through faulted and fragmented rock. For the electrical transmission cable tunnel, planned in the 1970's, the concern related to water ingress and caused the selection of a deep alignment for the tunnel at 400-500 metres below sea level. This placed the tunnel in the Precambrian gneiss layers that were considered to be significantly less permeable than the sedimentary rock layers above. For this cable tunnel, the deep alignment, with shoreline shaft was a viable alternative. For a transportation tunnel, such a deep alignment with typical downgrades and upgrades would result in a length that would cause a tunnel to be prohibitively expensive. Fortunately, developments in tunnel excavation techniques in the last 20 years have made possible a shallower tunnel within the sedimentary layer.

For the drill-and-blast tunnelling, water ingress must be reduced by grouting ahead of the tunnel face to seal water paths. This is not absolutely reliable in preventing water ingress and therefore an alignment below the sea bed at approximately 60 metres has been selected for this study. For the bored tunnel option, the tunnel lining is installed immediately as the tunnel is progressed and water ingress is prevented, hence the tunnel may be constructed closer to the seabed level.

4.3.1 Bored Tunnel

A bored tunnel would be constructed by an earth pressure balance tunnel boring machine (TBM). This type of TBM is designed to apply pressure to the excavation face to support the ground and to counteract water pressure in fractures and fissures. For this type of machine, the selection of the vertical alignment for the tunnel requires a decision between installing the tunnel close to the sea bed to reduce the hydrostatic pressure acting on the machine or to lower the alignment at the risk of increasing hydrostatic pressure but improving separation between the tunnel and the sea bed. For this study, the highest practicable alignment, at about 10 metres cover to the sea bed, has been selected. At this elevation the tunnel would be exposed to about 11 atmospheres of pressure, a level that has precedent on the Channel Tunnel.

A 'state of the art' earth pressure balance TBM, as shown in Figure 4.5, is capable of excavating the tunnel with minimal ingress of water and it does this by means of an auger screw for muck removal that penetrates a sealed bulkhead just behind the machine's rotating cutter head. The muck is held in front of the bulkhead by controlling the speed of the auger to create the support pressure at the excavation face. Excavated material from the rotating auger at the tunnel face would be deposited onto a conveyor belt, that in turn feeds muck cars that are hauled to the surface by locomotives. The cutter head would be fully configured for rock conditions, with rotating disk cutters used to ensure efficient cutting at the tunnel face. This type of machine is very suitable for use within the sedimentary rocks to be found within the Strait of Belle Isle crossing. These machines have frequently been configured to efficiently excavate these materials. The machines will be equipped with cutting tools specifically designed to handle the limestones and sandstones and will be protected with abrasion resistant plates to minimise the effects of the abrasive sandstones.

As the tunnel is advanced, the tunnel is lined with bolted precast concrete segments that are used in combination with the TBM. These lining segments are erected within the tailskin of the machine and therefore ensure that the tunnel workers have overhead cover at all times. The concrete segmental rings form the final lining to the tunnel and are generally made from high performance concrete with pre-installed rubber gaskets capable of fully sealing the joints between adjacent segments, and therefore permit construction of a watertight tunnel. Such precast concrete segmental tunnel linings would be manufactured in a local pre-casting facility.

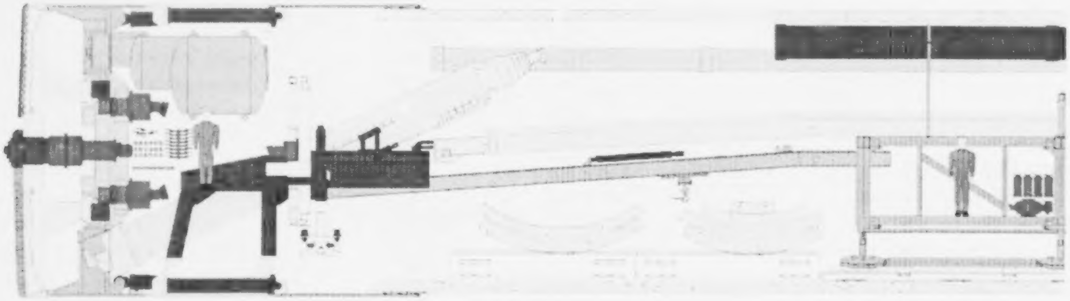

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Figure 4.5 - Schematic Detail of Earth Pressure Balance Type TBM

Vertical profiles for both road and rail tunnels are shown in Figures 4.6 and 4.7 respectively. The variation from one to the other is due to the flatter approach grades required on the railway tunnel.

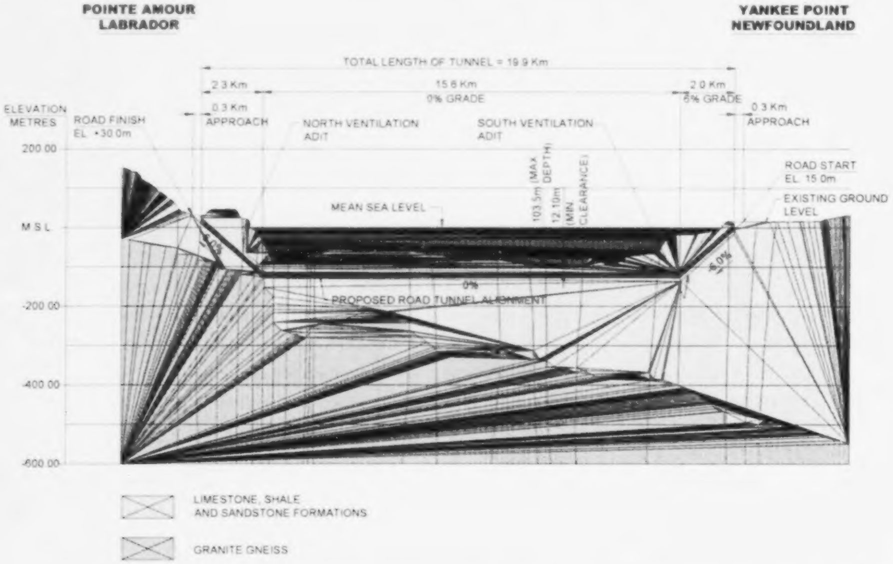

POINTE AMOUR
LABRADOR
YANKEE POINT
NEWFOUNDLAND
TOTAL LENGTH OF TUNNEL = 19.9 Km
2.3 Km
15.6 Km
0% GRADE
2.0 Km
6% GRADE
0.3 Km
APPROACH
0.3 Km
APPROACH
ELEVATION
METRES
ROAD FINISH
EL. +30.0m
NORTH VENTILATION
ADIT
SOUTH VENTILATION
ADIT
ROAD START
EL. 15.0m
EXISTING GROUND
LEVEL
MEAN SEA LEVEL
103.5m (MAX DEPTH)
12.10m (MIN. CLEARANCE)
200.00
M.S.L.
-200.00
-400.00
-600.00
6.0%
0%
6.0%
PROPOSED ROAD TUNNEL ALIGNMENT
LIMESTONE, SHALE
AND SANDSTONE FORMATIONS
GRANITE GNEISS

Figure 4.6 - Vertical Profile for a TBM Bored Road Tunnel

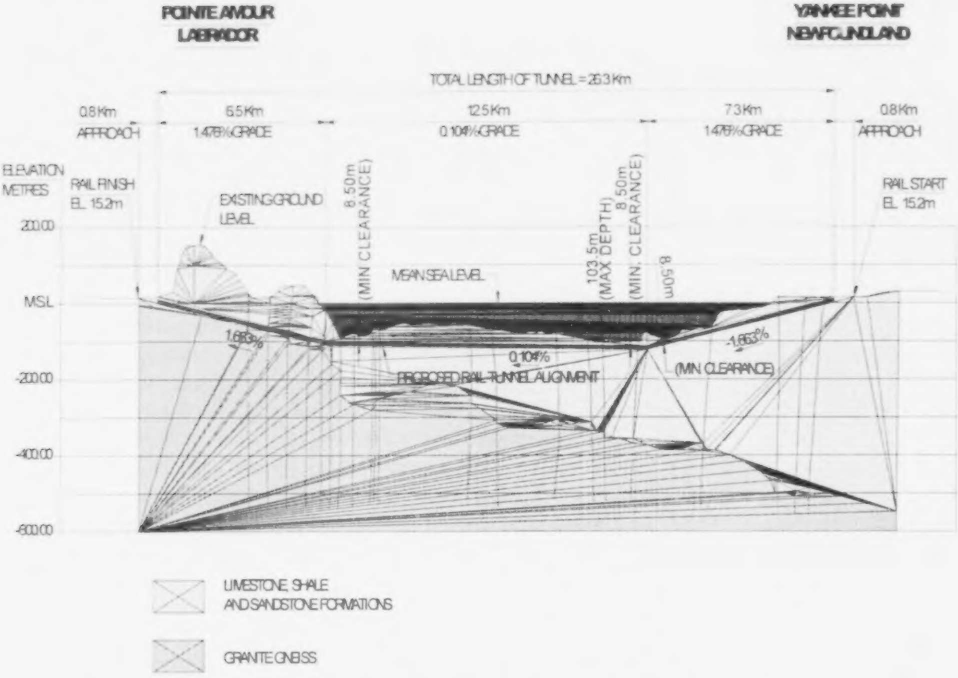

POINTE AMOUR
LABRADOR
YANKEE POINT
NEWFOUNDLAND
TOTAL LENGTH OF TUNNEL = 26.3 Km
0.8 Km
APPROACH
6.5 Km
1.476% GRADE
12.5 Km
0.104% GRADE
7.3 Km
1.476% GRADE
0.8 Km
APPROACH
ELEVATION METRES
RAIL FINISH
EL. 15.2m
EXISTING GROUND LEVEL
8.50m (MIN CLEARANCE)
MEAN SEA LEVEL
103.5m (MAX DEPTH)
8.50m (MIN. CLEARANCE)
8.50m
RAIL START
EL. 15.2m
200.00
MSL
-200.00
-400.00
-600.00
1.663%
0.104%
-1.863%
PROPOSED RAIL TUNNEL ALIGNMENT
(MIN CLEARANCE)
LIMESTONE, SHALE AND SANDSTONE FORMATIONS
GRANITE GNEISS

Figure 4.7 - Vertical Profile for a TBM Bored Rail Tunnel

The cross-section shown in Figure 4.8 for a bored road tunnel allows 24 m^2 of total ventilation duct space, and therefore fulfils the duct area requirements for ventilation zones 2, and 4 and exceeds that for Zone 3 (as identified in Section 3). It has therefore been assumed that ventilation adits will be constructed alongside the tunnel within ventilation Zones 1 and 5. It can be seen that this ventilation requirement contributes significantly to the tunnel internal diameter requirement of 11.0 metres

Figure 4.9 shows the conceptual cross-section for a bored rail tunnel. It can be seen that the rail cross-section benefits from the reduction in ventilation requirements and spatial requirements for the vehicles giving a much smaller internal diameter of 7.5 metres.

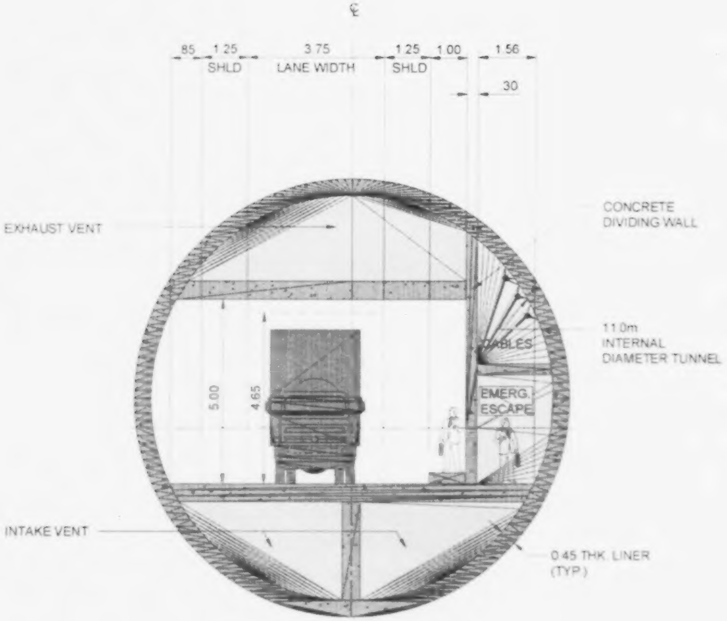

℄
.85
1.25
SHLD
3.75
LANE WIDTH
1.25
SHLD
1.00
1.56
.30
EXHAUST VENT
CONCRETE DIVIDING WALL
11.0m INTERNAL DIAMETER TUNNEL
CABLES
EMERG. ESCAPE
5.00
4.65
INTAKE VENT
0.45 THK. LINER (TYP.)

Figure 4.8 - TBM Bored Road Tunnel Conceptual Cross Section

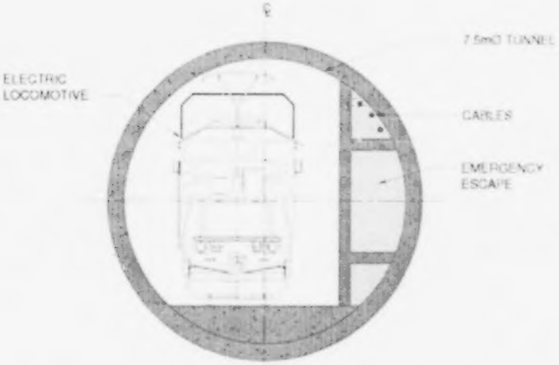

℄
7.5mØ TUNNEL
ELECTRIC LOCOMOTIVE
CABLES
EMERGENCY ESCAPE

Figure 4.9 - TBM Bored Rail Tunnel - Conceptual Cross Section

Approaches

Figures 4.10 and 4.11 show representative, not-to-scale conceptual layouts (overlaid on topographical maps) for the north (Labrador) and south (Island of Newfoundland) approaches for the bored road tunnel concept. These layouts show approximate tunnel portal locations, proposed locations of vehicle waiting areas, new roads, and points of connection to the existing road systems on either side of the Strait. It is anticipated that

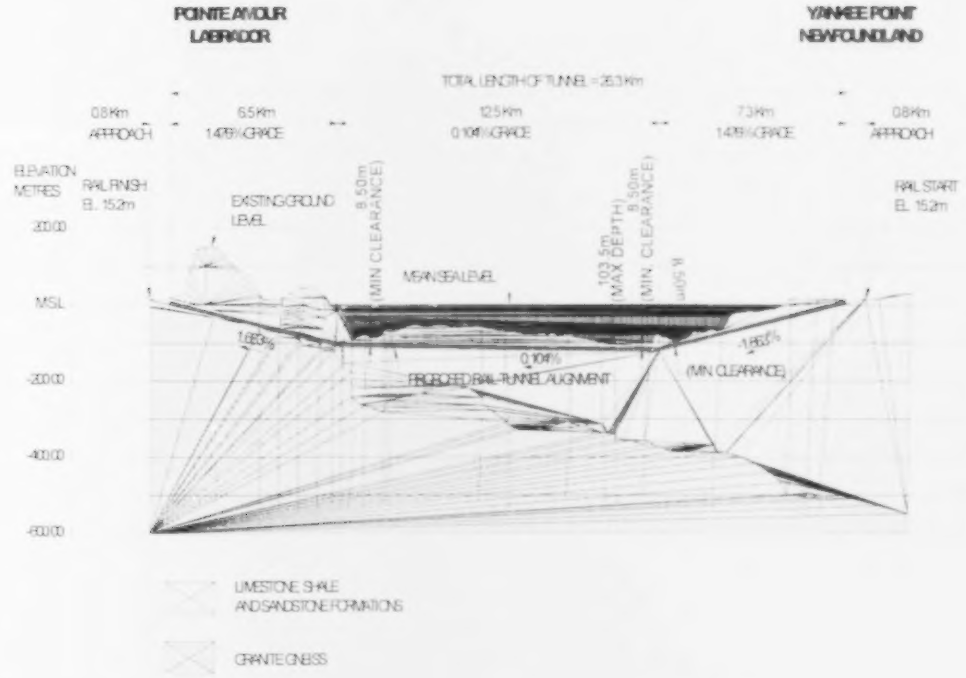

POINTE AMOUR
LABRADOR
YANKEE POINT
NEWFOUNDLAND
TOTAL LENGTH OF TUNNEL = 26.3 Km
0.8 Km APPROACH
6.5 Km 1.478% GRADE
12.5 Km 0.104% GRADE
7.3 Km 1.478% GRADE
0.8 Km APPROACH
ELEVATION METRES
RAIL FINISH EL. 15.2m
RAIL START EL. 15.2m
EXISTING GROUND LEVEL
8.50m (MIN CLEARANCE)
MEAN SEA LEVEL
103.5m (MAX DEPTH)
8.50m (MIN. CLEARANCE)
8.50m
200.00
MSL
-200.00
-400.00
-600.00
1.663%
0.104%
-1.663%
PROPOSED RAIL-TUNNEL ALIGNMENT
(MIN CLEARANCE)
LIMESTONE SHALE AND SANDSTONE FORMATIONS
GRANITE GNEISS

Figure 4.7 - Vertical Profile for a TBM Bored Rail Tunnel

The cross-section shown in Figure 4.8 for a bored road tunnel allows 24 m^2 of total ventilation duct space, and therefore fulfils the duct area requirements for ventilation zones 2, and 4 and exceeds that for Zone 3 (as identified in Section 3). It has therefore been assumed that ventilation adits will be constructed alongside the tunnel within ventilation Zones 1 and 5. It can be seen that this ventilation requirement contributes significantly to the tunnel internal diameter requirement of 11.0 metres

Figure 4.9 shows the conceptual cross-section for a bored rail tunnel. It can be seen that the rail cross-section benefits from the reduction in ventilation requirements and spatial requirements for the vehicles giving a much smaller internal diameter of 7.5 metres.

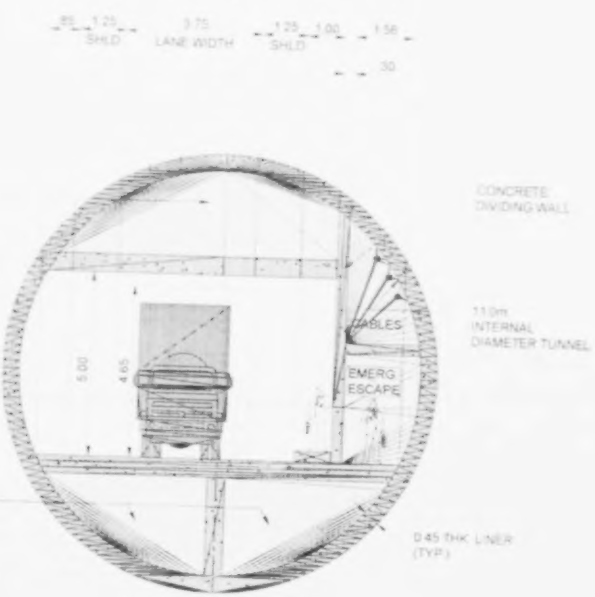

℄
.85
1.25
SHLD
3.75
LANE WIDTH
1.25
SHLD
1.00
1.56
.30
EXHAUST VENT
CONCRETE DIVIDING WALL
CABLES
11.0m INTERNAL DIAMETER TUNNEL
5.00
4.65
EMERG ESCAPE
INTAKE VENT
0.45 THK LINER (TYP.)

Figure 4.8 - TBM Bored Road Tunnel Conceptual Cross Section

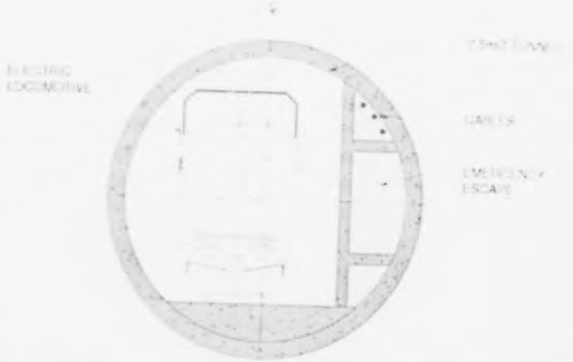

ELECTRIC LOCOMOTIVE
CABLES
EMERGENCY ESCAPE

Figure 4.9 - TBM Bored Rail Tunnel - Conceptual Cross Section

Figures 4.10 and 4.11 show representative, not-to-scale conceptual layouts (overlaid on topographical maps) for the north (Labrador) and south (Island of Newfoundland) approaches for the bored road tunnel concept. These layouts show approximate tunnel portal locations, proposed locations of vehicle waiting areas, new roads, and points of connection to the existing road systems on either side of the Strait. It is anticipated that these layouts would be broadly similar for the drill and blast tunnel, immersed tube tunnel, bridge, and causeway options. The latter two would not require vehicle waiting areas, however.

The north approach has a 6% grade, which permits it to connect with an existing access road to Pointe Amour, which also has a similar grade. Assuming 6 metres of cover over the tunnel at the portal location, a 33 meters long reinforced concrete box approach structure will be required to connect the tunnel to the existing access road. For the current conceptual cost estimating purposes, it has been assumed that the excavation for the approach structure will be undertaken using drill & blast techniques.

The south approach also has a 6% grade with the tunnel 'daylighting' some 500 metres inland from the Newfoundland shore. A 330-meters long reinforced concrete box approach structure, also assumed to be excavated using drill & blast techniques, connects the bored tunnel to existing ground level at Yankee Point.

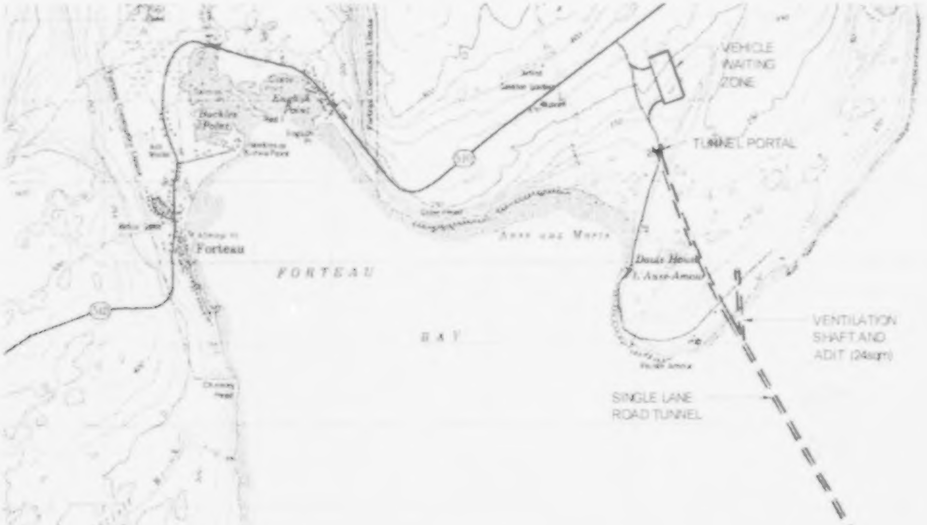

VEHICLE WAITING ZONE
TUNNEL PORTAL
VENTILATION SHAFT AND ADIT (24sqm)
SINGLE LANE ROAD TUNNEL
English Point
Buckles Point
Forteau
FORTEAU
BAY
Anse aux Morts
Dads Head
L'Anse-Amour
510

Figure 4.10 - Road Tunnel Approach Layout - Labrador Side

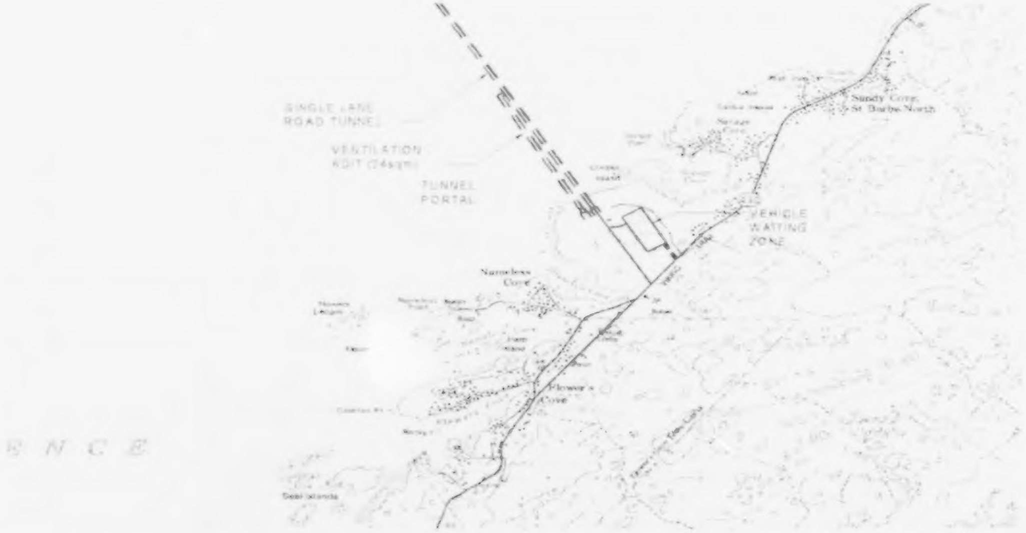


Figure 4.11 - Road Tunnel Approach Layout - Newfoundland Side

Figures 4.12 and 4.13 show conceptual layouts for the north and south approaches for the bored rail tunnel concept. These layouts show approximate tunnel portal locations, rail terminals, new roads, and points of connection to existing road systems on either side of the Strait. These layouts would be broadly similar for the drill and blast tunnel and immersed tube tunnel rail options.

The configuration for the north approach to the rail tunnel is governed by the requirement to provide a relatively flat area for siting of the north rail terminal. The only available area of this type lies to the north of English Point, and the railway tunnel swings westwards beneath Pointe Amour and Anse aux Morts and runs at an approximate grade of 1.6% to connect with this location. Assuming 4 metres of cover to the tunnel at the portal location, a 750 metres long reinforced concrete box approach structure is required to connect the tunnel to ground level.

The general topography on the south side is much flatter than on the Labrador side, and it appears that there are a number of locations where the south rail terminal could be located. For present purposes it has been sited to the east of Flower's Cove in a location which appears to minimise the length of new road construction to connect to the rail terminal, and without apparent adverse impact on the nearby local communities around Flower's Cove and Nameless Cove. Assuming 4 metres of cover at the tunnel portal, a 770 metres long reinforced concrete box approach structure is required to connect the tunnel to ground level.

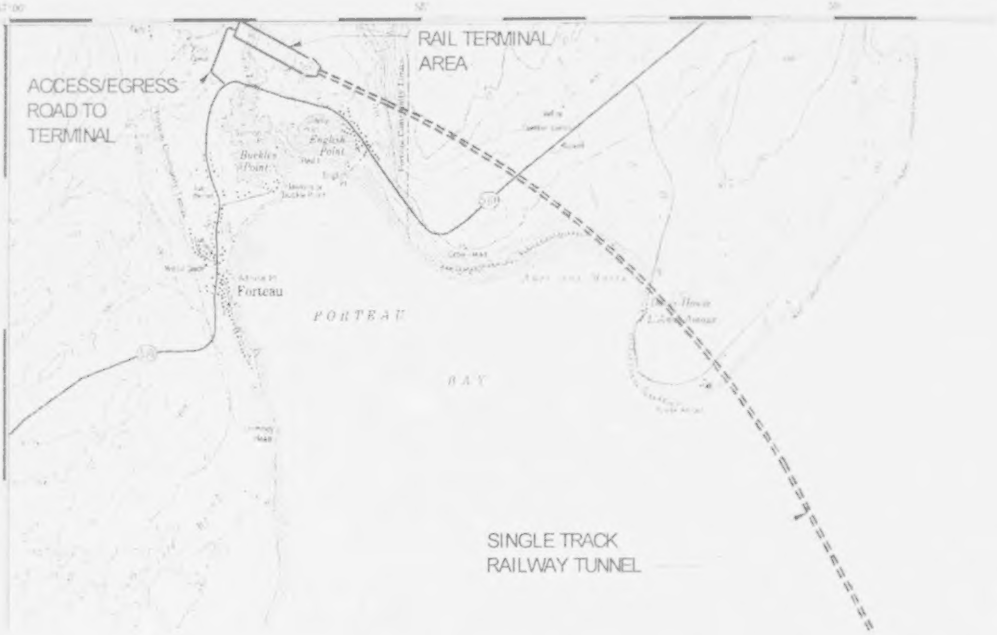

RAIL TERMINAL AREA
ACCESS/EGRESS ROAD TO TERMINAL
English Point
Buckles Point
Forteau
FORTEAU
BAY
SINGLE TRACK RAILWAY TUNNEL

Figure 4.12 - Rail Tunnel Approach Layout- Labrador Side

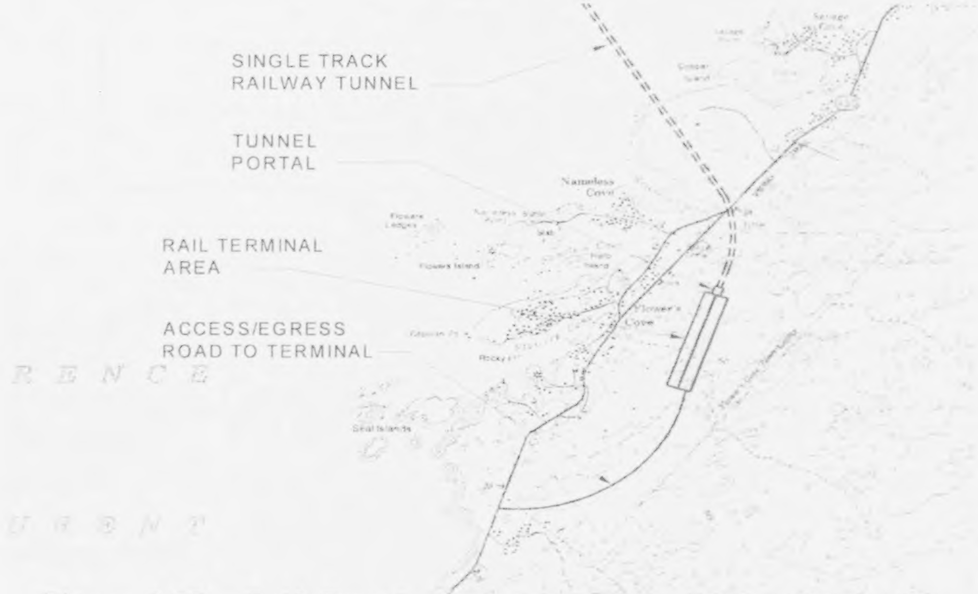

SINGLE TRACK RAILWAY TUNNEL
TUNNEL PORTAL
RAIL TERMINAL AREA
ACCESS/EGRESS ROAD TO TERMINAL
Nameless Cove
Flower's Cove
Flowers Island
Seal Islands
RENCE
UENT

Figure 4.13 - Rail Tunnel Approach Layout- Newfoundland Side

Road Connections and Terminus Facilities

The description which follows of the roads connecting to a fixed link and the required facilities at each terminus is common to all three tunnelling construction concepts. For a bridge or causeway link, it would be sufficient to connect to the existing local roads without marshalling facilities. The description supports the terminus facility concepts presented above.

The link would be accessed on the Newfoundland side from the highway along the Great Northern Peninsula and on the Labrador side from an extension of the road along the north shore of the Gulf of St. Lawrence or from the TransLabrador Highway.

On the Newfoundland side, the nearest communities to Yankee Point are Savage Cove, about 2 kilometres to the north, and Flower's Cove, about 1 kilometre to the south. Yankee Point itself is approximately 900 metres west of provincial highway Route 430 which runs north-south along the Northern Peninsula from Deer Lake to St. Anthony.

Route 430 is a paved, all-season, two-lane road and is classified as a Rural Collector Undivided (RCU 80) road with a design speed of 80 kilometres per hour. Its condition varies over its length and is rated as being in poor to good condition; some sections could be improved by simple resurfacing while others will need significant re-construction. Although some condition assessments have been done and requirements developed for upgrading work, a commitment of funding or timing for the implementation of upgrading projects has not been made. Work will be highly dependent on the availability of funding.

For a distance of 5 kilometres north and south of Yankee Point, the highest elevation of the highway is about 15 metres with a significant portion of it being below 5 metres elevation. Grades along this section of highway are fair to gentle. Horizontal alignment is very good. Traffic along this section of highway is mostly locally generated from neighboring communities; through traffic would be connecting to other communities or else would be traveling north to St. Anthony or south to the ferry terminal at St. Barbe or on to Deer Lake. A considerable amount of tourist traffic uses the road during the summer months on route to L'Anse aux Meadows and other destinations along the Viking Trail.

The terrain in this general area is characterized by coastal low lands and sloping bog plateaus. There are a considerable number of ponds in the backland, which rises gently (less than 1%) to the east to elevation 60 m at 7 kilometres from the shore.

For a road tunnel option, only 0.5 kilometre of new road construction will be needed to connect the tunnel with the existing road system. At the tunnel entrance, there will be a need for a paved marshalling area to accommodate vehicles waiting to enter the tunnel. The parking lot would be sized to accommodate the equivalent of approximately 600 passenger car units and would cover about 1.8 hectares.

For the railway tunnel option, 3 kilometres of new road will be needed to connect the rail terminal with the existing road.

On the Labrador side, Pointe Amour is reached via a 3 kilometres narrow, gravel road from Route 510; this road connects to the Trans Labrador Highway at Red Bay about 50 kilometres north, and runs another 260 kilometres further north to Cartwright. The nearest communities to Pointe Amour are Forteau, about 8 kilometres to the south, and L'Anse aux Loup, about 3 kilometres to the north.

To the south of Pointe Amour, the paved road runs 20 kilometres to the Quebec border at Blanc Sablon and then extends west into Quebec to Middle Bay for another 25 kilometres. A 40 kilometre long gravel road exists from there to Vieux Forte; its condition is not known. The nearest community along the Quebec North Shore with road access to the Quebec highway system is Natashquan, which is about 370 kilometres to the southwest. It is this distance that would require road construction to provide a continuous southern connection between the Fixed Link across the Strait of Belle Isle and points further west. Discussions with government officials in Quebec indicate that planning studies have been undertaken for this road construction. Upgrading of the 40 kilometres of existing gravel road from Middle Bay to Vieux Forte will likely be required as well.

The section of highway in the Pointe Amour area is a paved, all-season, two-lane road and is classified as a Rural Local Undivided (RLU 80) road with a design speed of 80 kilometres per hour. The condition of this road is rated as fair to good. The highway to the north of Red Bay is a new gravel road and is classified as a modified Rural Local Undivided (RLU 60).

For a distance of 5 kilometres near the Point Amour turn-off, Route 510 is at an elevation of about 100 metres while at Forteau and L'Anse aux Loup it drops below 15 metres elevation. Grades along the highway in this area are fair to steep. In terms of horizontal alignment, the road winds through the communities and is straight across country at the Pointe Amour turn-off.

Traffic along this section of highway is mostly locally generated from neighboring communities; through traffic would be connecting to other communities or else would be traveling north to the Trans Labrador Highway or south to the ferry terminal at Blanc Sablon. Tourist traffic uses the road during the summer months on route to Red Bay and other destinations along the Labrador Straits.

For the road tunnel option, 2 kilometres of new road construction will be needed to connect the existing road to the tunnel. The marshalling will be similar to that described above for the Newfoundland side. For the rail tunnel option, 1 kilometre of new road construction will be needed to connect the terminal area with the existing road.

Rail System Requirements

The requirements of a rail shuttle system are as follows:

- Electric locomotives fed from a fixed overhead catenary system (OCS)
- Two flat deck cars used for loading and unloading from each end of the train
- Enclosed single level cars to hold 126 cars or 42 highway trucks (or combinations)
- Tunnel train signal system
- Loading and unloading fixed facilities
- Emergency response and maintenance vehicles
- Rolling stock maintenance facilities
- Toll collection, public and staff convenience facilities
- Operating and maintenance staff

The shuttle train consists of transfer and vehicle cars. The former are basically standard-size flat cars, typically 27.5 metres (90 ft) long with the regular timber-faced flat replaced with a durable driving surface. They weigh approximately 25 tonnes. The latter are single-level enclosed cars, with access through each end to enable the train to be loaded by driving through from the transfer car. The configuration is based on a standard 27.5 metres bi-level auto carrier but in order to be able to accommodate a mix of trucks and cars, only a single level will be used. Bi-level cars can typically handle ten large vehicles so a single level car is assumed to accommodate six vehicles. The actual rail cars will need to be purpose-built with sufficient internal width to accommodate trucks and to enable automobiles to be driven along the length of the train by untrained drivers. All vehicles will need to be secured with tie-downs or clamps to enable operation of the train at the design speed.

Auto carriers weigh around 36 tones unloaded. The governing case for train weight will be a fully loaded tractor-trailer on a single carrier car. Truck weights in Canada vary considerably; for the purposes of this study, an average truck weight of 36 tonnes is assumed which corresponds to the US Federal highway 80,000 lb maximum. To accommodate 126 cars, each train will require 21 of these cars, and these can be arranged in 3-car or 5-car articulated "packs" with shared bogies.

Locomotives are sized for the total train weight and the performance requirements. For a 100 kilometres per hour average speed, 1.5 percent ruling grades and the friction losses associated with operating in a tunnel, the power required is 1.6 kW per tonne (2.0 bhp per ton) of train weight. Therefore nominal power requirements are 3000 kW (4000 bhp), which is well below the typical 4 to 5 MW rating of European freight locomotives. Operation of the train will require control of the locomotive from a cab on one of the flat cars, controlling the train when operating with the locomotive at the rear.

The OCS would consist of a 25 kV single phase system fed from substations at each terminal site. The catenary would be supported on 30 metres centres in the tunnel and average 55 metres spans at the terminals. For the 25 kilometres tunnel, a low profile copper conductor OCS, messenger, contact wire, and neutral wire are assumed. The OCS is fixed using overlaps at every 1600 metres and is supported at every 30 metres average using a drop tube from the ceiling and attaching a small cantilever. Neutral wire can be attached to a drop pipe. A disconnect switch will be used at each end of the tunnel. A phase break will be required in the middle of the tunnel with a disconnect switch.

At each of the terminals, approximately 2,670 track metres need to be electrified. At this stage the assumption is that a copper conductor OCS, messenger, contact wire, and neutral wire will be supported from cantilevers attached to steel wide flange poles. The poles will be mounted on cast-in-place concrete foundations. The OCS will be auto-tensioned using counterweight assemblies. Tracks will be isolated electrically using section insulators and disconnect switches. The maintenance facility will have a single wire supported at 25-meter intervals. A section insulator and a switch will be required.

At each end of the tunnel, there are facilities for loading and unloading shuttle trains. The actual configuration of these will depend upon the sites selected and the final vehicle storage capacity required. Typically they will include train storage tracks, ramps, vehicle staging area, toll booths, public restrooms, maintenance shed, etc.

Capital Cost Estimate

To estimate the construction cost of a bored tunnel, the HMM tunnel estimating database (TED 2001) was used. This database has information on labour and equipment requirements and advance rates from other similar TBM bored tunnelling projects, and these are used in the development of a contractor style estimate. Where applicable, labour rates for Newfoundland were used. The cost includes the connecting roads on each side of the Strait (but not for a highway along the north shore of the Gulf of St. Lawrence nor any upgrade of Highway 430), marshalling areas and the installation of HVDC cables.

Principal assumptions used in preparation of the estimates are as follows:

Earth pressure balance type TBM, used to mine the tunnel starting from the Island of Newfoundland side of the Strait.

Bolted precast concrete liners installed behind the TBM as it advances – these are assumed to be manufactured in the Province of Newfoundland and Labrador.

Labour conditions and wages as outlined in the collective agreement between the Construction Labour Relations Association of Newfoundland and Labrador Inc (CLRA) and LIUNA, Local 1208, Construction, Rock and Tunnel and General Workers Union, June 2003

TBM advance rates of 14 metres per day and 17.7 metres per day where rock conditions are good, for highway and railway tunnels respectively

TBM advance rates of 5.5 metres per day and 7.1 metres per day in faulted zones which are assumed to occur over a 1400 metre length of the tunnel alignment, for highway and railway tunnels respectively

8-week long learning curve at commencement of tunnelling where advance rates are 50% of those achieved when the crews are experienced.

40% contingency applied to civil elements of the work

20% contingency applied to mechanical and electrical elements of the work

15% contractor's overheads and profit applied to the estimate

17% applied to the overall estimate for design, construction management, and owner's costs.

$15 million for feasibility study and environmental assessment

The construction cost of the road tunnel option is estimated to be $1,559 million in 2004 dollars and the cost of the rail tunnel is estimated to be $1144 million. A detailed cost breakdown of both estimates is provided in Appendix D.

Operating & Maintenance Costs

At a pre-feasibility study level, the O&M costs will be similar for all three tunnel concepts. Expenditures associated with the operation of a road tunnel can be categorised as follows:

Management and operation of the tunnel control building

Traffic supervision costs – closed circuit television will be used for monitoring of the tunnels, with full time monitoring taking place at the surface within the tunnel control building

Emergency truck costs – these are required for the removal of broken down vehicles from the tunnel, and for carrying emergency fire fighting equipment. One emergency truck will be required at each portal, and these should be stationed close to the portals downstream of the traffic flow. Fully trained operators and an assistant will be required for each truck on a 24-hour basis.

Energy costs associated with the operation of the control centre, tunnel vehicles, tunnel ventilation equipment, and drainage pumps.

Electrical maintenance costs associated with the inspection and maintenance of the power distribution system (includes switchgear, transformers, wiring, and cabling), tunnel lighting, communication and signal systems. A platform truck is required for maintenance of the tunnel lighting system.

Mechanical maintenance costs associated with the inspection and maintenance of the tunnel ventilation system, emergency diesel generators, and drainage pumps.

Structure maintenance costs associated with the inspection, cleaning, and maintenance of the roadway, drainage sumps, and tunnel structure. A street cleaner vehicle is required for cleaning of the roadway, and a washing truck for frequent cleaning of the tunnel walls and soffit.

Estimated operating and maintenance cost for the highway tunnel option are $6.8 million per annum in 2004 dollars. Appendix E provides a breakdown of these costs.

Expenditure associated with the operation of a rail tunnel can be categorized as follows:

Energy costs associated with the operation of tunnel lighting, equipment, and drainage pumps - the majority of these costs will be for the supply of electrical power and will therefore vary with fluctuations in market costs for electricity

Electrical maintenance costs associated with the inspection and maintenance of the power distribution system (includes switchgear, transformers, wiring, and cabling), tunnel lighting, communication and signal systems

Mechanical maintenance costs associated with the inspection and maintenance of the tunnel ventilation system, emergency diesel generators, and drainage pumps

Structure maintenance costs associated with the inspection, cleaning and maintenance of the permanent way, drainage sumps, and tunnel structure

For tunnelling projects, it is typical for contingencies at a pre-feasibility stage to range from 40% to 75%. The selection of contingency level is particularly related to the existance or lack of geotechnical investigation. Typically at this stage no investigation has taken place. For this project, a contingency of 40% has been chosen for the tunnel (civil) costs since a conceptual geotechnical investigation has taken place, several years earlier, and therefore the lower end of the range of contingency levels can be used.

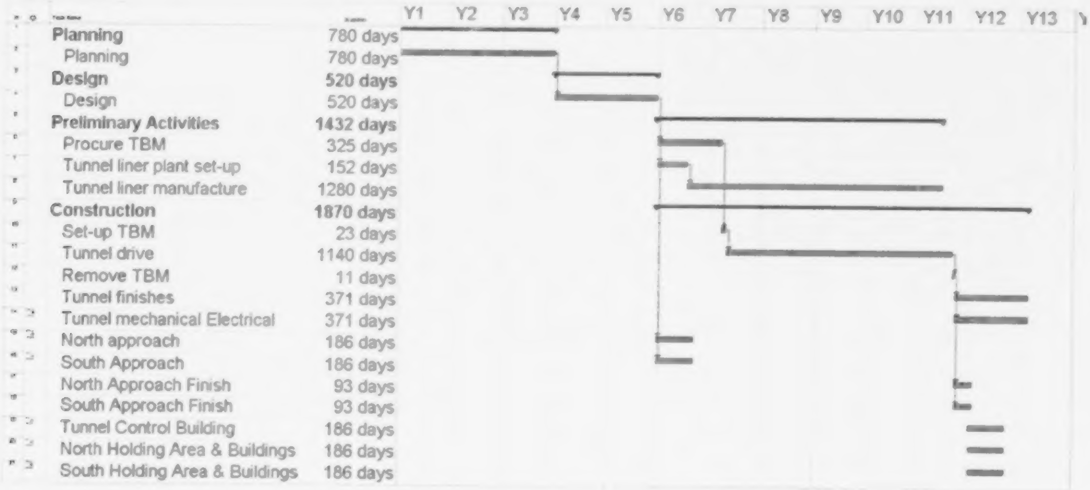
Estimated operating costs for the rail tunnel alone are $0.9 million per annum in 2004 dollars. The estimated operating costs for the train shuttle are $6.74 million for a total of $7.64 million. Appendix F provides a breakdown of these costs.

Construction Schedule

A major factor in the schedule for a bored tunnelling operation is the procurement of the TBM and manufacture and supply of precast concrete lining rings in advance of commencement of tunnelling operations. Experience on other major projects has demonstrated that TBM procurement / manufacture can normally take up to 15 months, and such a period has therefore been allowed for the scheduling of the TBM tunnel options.

The schedule for construction of the road tunnel option is shown in Figure 4.14. The estimated duration from project commencement is 146 months, assuming 36 months for planning activities and 24 months for tunnel design. This schedule assumes that the tunnelling work is undertaken by a single TBM operating from the Newfoundland side.

The schedule for construction of the railway option is similar to that for the road tunnel with an additional 4months because the tunnel is longer to account for the lower grades on the approaches. Using a single TBM results in an overall construction schedule of 150 months.



Planning	780 days
Planning	780 days
Design	**520 days**
Design	520 days
Preliminary Activities	**1432 days**
Procure TBM	325 days
Tunnel liner plant set-up	152 days
Tunnel liner manufacture	1280 days
Construction	**1870 days**
Set-up TBM	23 days
Tunnel drive	1140 days
Remove TBM	11 days
Tunnel finishes	371 days
Tunnel mechanical Electrical	371 days
North approach	186 days
South Approach	186 days
North Approach Finish	93 days
South Approach Finish	93 days
Tunnel Control Building	186 days
North Holding Area & Buildings	186 days
South Holding Area & Buildings	186 days

Figure 4.14 - TBM Bored Road Tunnel Construction Schedule (1 TBM)

4.3.2 Drill and Blast

A drill & blast tunnel would be located in the sedimentary layer at a depth below the seabed level of approximately 60 metres between the seabed and the crown of the tunnel. Unlike the TBM bored tunnel option, it is considered inadvisable to locate the drill & blast tunnel only one tunnel depth below the seabed since the drill and blast technique does not provide immediate support or against water pressure, and blasting operations could open up a previously undiscovered zone of weak or faulted rock with serious consequences for the tunnel construction. The drill & blast tunnel options are therefore 0.3 kilometre and 4.4 kilometres longer than the respective road and rail tunnels constructed using TBM.

Even with the lowered alignment, tunnelling using drill and blast techniques must include measures to reduce the risk of major water inflows into the tunnel. These measures would typically consist of drilling probe holes ahead of the excavation (usually about 30 or 40 metres ahead) to detect potential inflows. Should an inflow be detected, then a series of additional holes are drilled to allow pumping of pressurized cement grout into the rock joints and pressures and into zones of broken rock, ahead of the excavation face. This process can require repeated operation before the inflow is reduced to an acceptable level. The grouting may have to deal with hydrostatic pressures of up to 17 atmospheres. This is not considered a problem. (HMM is presently managing such a grouting program in a tunnel in California where hydrostatic pressures are 30 atmospheres).

The cost estimate and schedule allow for full coverage in terms of maintaining a probe hole drilled ahead of the excavation face and for grouting of 10% of the length of the tunnel. As might be expected this amount of grouting has a significant negative effect on the overall advance rate for the tunnel.

There will likely be some degree of seepage at all times and a cast-in-place concrete liner would have to be installed within the tunnel on completion of drill & blast operations. Collapsible travelling steel forms are generally used for forming such liners with concrete transported to the required location by means of pipeline or agitator cars that prevent early setting of the concrete prior to placement.

For drill & blast operations, excavated material can be removed from the tunnel by means of locomotive and muck cars, or by rubber tired trucks, which travel between the tunnel face and the surface. Because of likely ventilation problems in such a long tunnel, the former method would likely be required. Profiles for the road and rail tunnel concepts are shown in Figures 4.15 and 4.16 respectively.

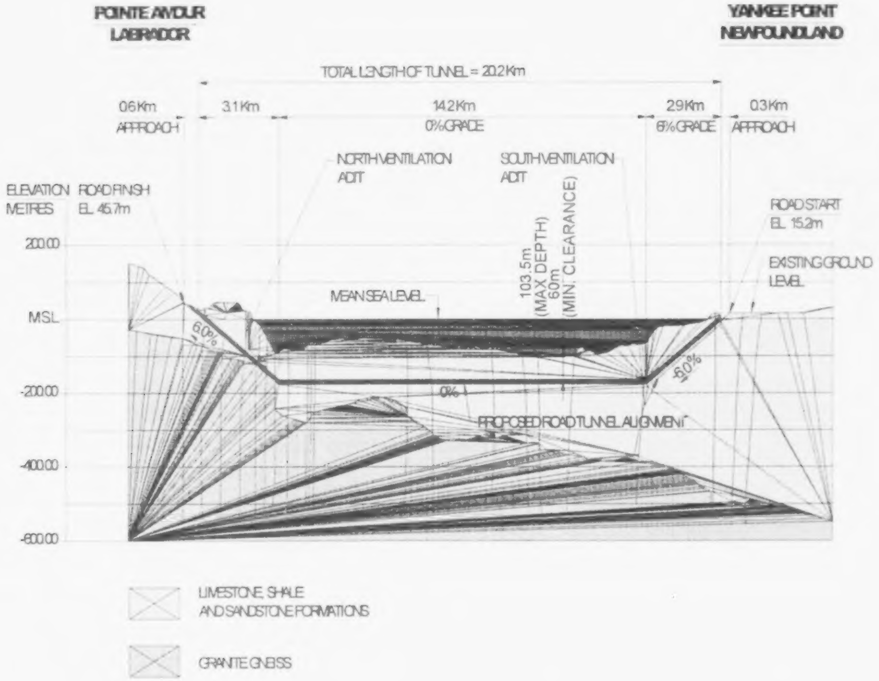

POINTE AMOUR
LABRADOR
YANKEE POINT
NEWFOUNDLAND
TOTAL LENGTH OF TUNNEL = 20.2 Km
0.6 Km
APPROACH
3.1 Km
14.2 Km
0% GRADE
2.9 Km
6% GRADE
0.3 Km
APPROACH
NORTH VENTILATION
ADIT
SOUTH VENTILATION
ADIT
ELEVATION
METRES
ROAD FINISH
EL 45.7m
ROAD START
EL 15.2m
EXISTING GROUND
LEVEL
103.5m
(MAX DEPTH)
60m
(MIN. CLEARANCE)
MEAN SEA LEVEL
200.00
MSL
-200.00
-400.00
-600.00
6.0%
0%
6.0%
PROPOSED ROAD TUNNEL ALIGNMENT
LIMESTONE, SHALE
AND SANDSTONE FORMATIONS
GRANITE GNEISS

Figure 4.15 - Drill & Blast Road Tunnel Conceptual Profile

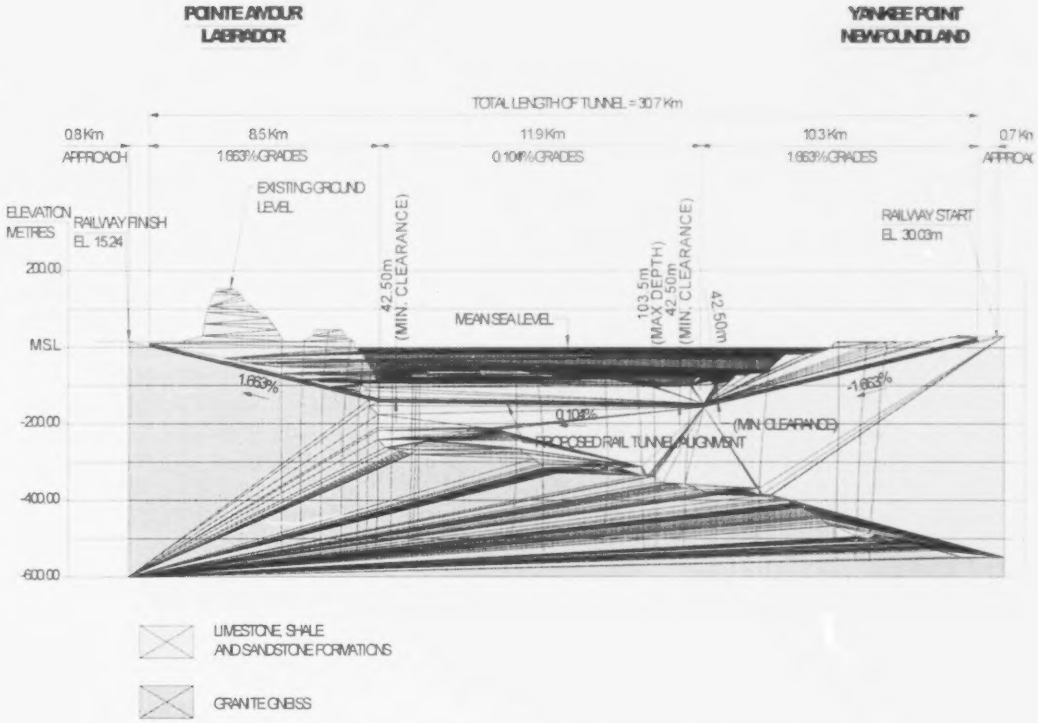

POINTE AMOUR
LABRADOR
YANKEE POINT
NEWFOUNDLAND
TOTAL LENGTH OF TUNNEL = 30.7 Km
0.8 Km
APPROACH
8.5 Km
1.663% GRADES
11.9 Km
0.104% GRADES
10.3 Km
1.663% GRADES
0.7 Km
APPROACH
EXISTING GROUND LEVEL
ELEVATION METRES
RAILWAY FINISH
EL. 15.24
RAILWAY START
EL. 30.00m
42.50m (MIN. CLEARANCE)
103.5m (MAX DEPTH)
42.50m (MIN. CLEARANCE)
42.50m
MEAN SEA LEVEL
200.00
M.S.L.
-200.00
-400.00
-600.00
1.663%
-1.663%
0.104%
(MIN. CLEARANCE)
PROPOSED RAIL TUNNEL ALIGNMENT
LIMESTONE, SHALE AND SANDSTONE FORMATIONS
GRANITE GNEISS

Figure 4.16 - Drill & Blast Rail Tunnel Conceptual Profile

Figures 4.17 and 4.18 show the conceptual cross-sections for the drill and blast road tunnel. The first shows a cross-section with no space provided for ventilation ducts; this section would apply to ventilation zone 3 where ventilation ducts are not required. The second shows a cross-section with approximately 24 m^2 of duct space, which satisfies the requirements of zones 2 and 4. However, this cross-section would also be constructed within ventilation zones 1 and 5 with additional separate and adjacent ventilation adits to make up the 24 m^2 shortfall in duct space. Figure 4.19 shows the conceptual cross-section for the rail tunnel.

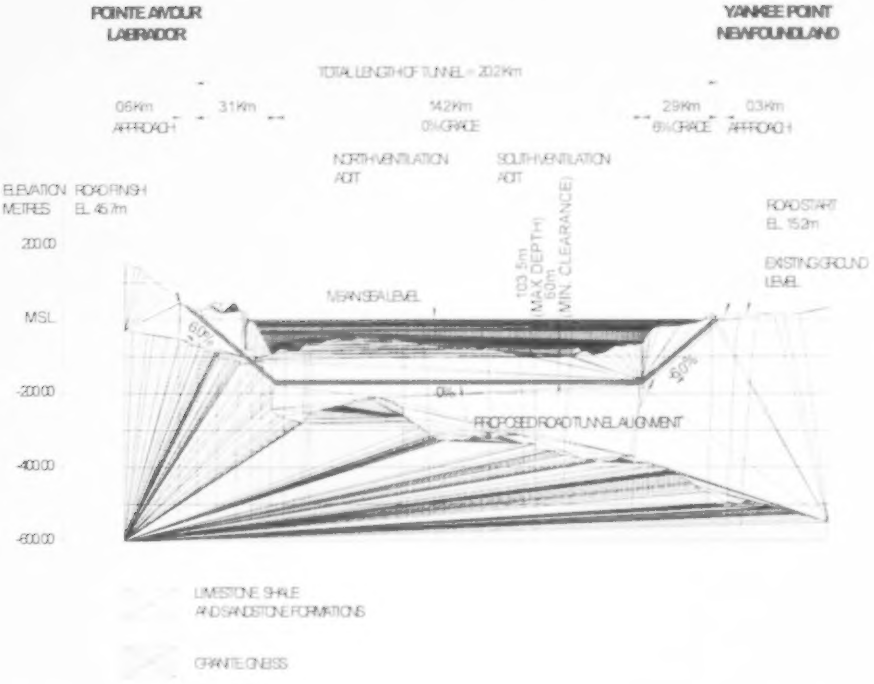

POINTE AMOUR
LABRADOR
YANKEE POINT
NEWFOUNDLAND
TOTAL LENGTH OF TUNNEL = 20.2Km
0.6Km
APPROACH
3.1Km
14.2Km
0% GRADE
2.9Km
6% GRADE
0.3Km
APPROACH
NORTH VENTILATION
ADIT
SOUTH VENTILATION
ADIT
ELEVATION
METRES
ROAD FINISH
EL. 45.7m
ROAD START
EL. 15.2m
EXISTING GROUND
LEVEL
103.5m
(MAX DEPTH)
60m
(MIN. CLEARANCE)
MEAN SEA LEVEL
200.00
MSL
-200.00
-400.00
-600.00
6.0%
6.0%
0%
PROPOSED ROAD TUNNEL ALIGNMENT
LIMESTONE SHALE
AND SANDSTONE FORMATIONS
GRANITE GNEISS

Figure 4.15 - Drill & Blast Road Tunnel Conceptual Profile

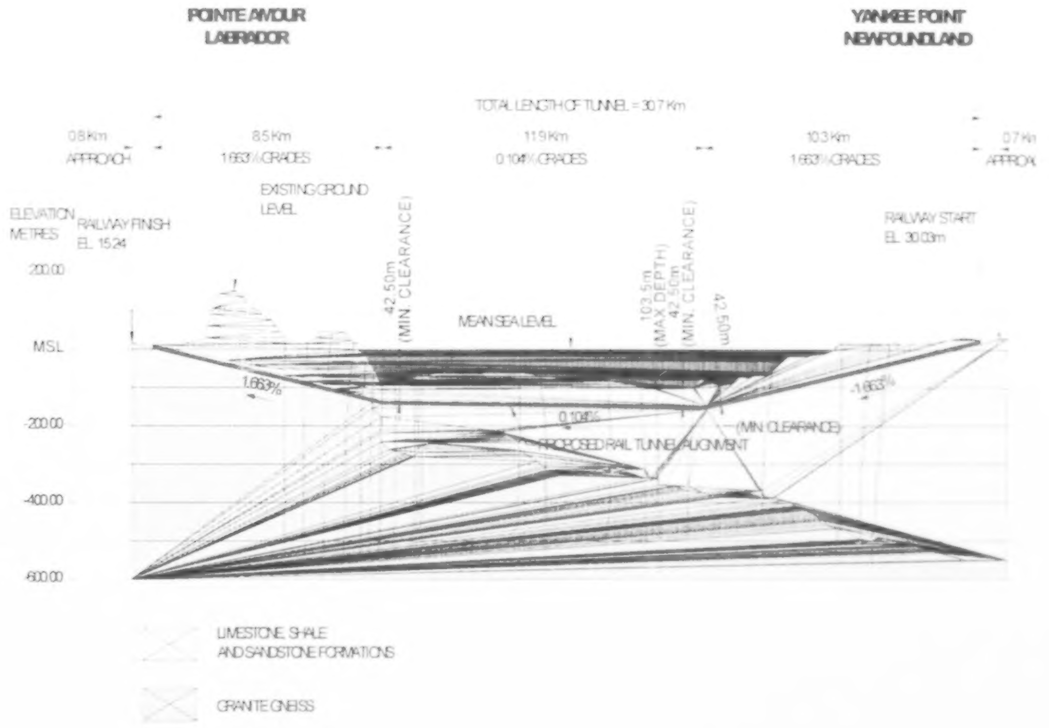

POINTE AMOUR
LABRADOR
YANKEE POINT
NEWFOUNDLAND
TOTAL LENGTH OF TUNNEL = 30.7 Km
0.8 Km
APPROACH
8.5 Km
1.663% GRADES
11.9 Km
0.104% GRADES
10.3 Km
1.663% GRADES
0.7 Km
APPROACH
EXISTING GROUND LEVEL
ELEVATION METRES
RAILWAY FINISH
EL. 15.24
RAILWAY START
EL. 30.03m
42.50m (MIN. CLEARANCE)
103.5m (MAX DEPTH)
42.50m (MIN. CLEARANCE)
42.50m
MEAN SEA LEVEL
200.00
MSL
-200.00
-400.00
-600.00
1.663%
0.104%
-1.663%
(MIN CLEARANCE)
PROPOSED RAIL TUNNEL ALIGNMENT
LIMESTONE, SHALE AND SANDSTONE FORMATIONS
GRANITE GNEISS

Figure 4.16 - Drill & Blast Rail Tunnel Conceptual Profile

Figures 4.17 and 4.18 show the conceptual cross-sections for the drill and blast road tunnel. The first shows a cross-section with no space provided for ventilation ducts; this section would apply to ventilation zone 3 where ventilation ducts are not required. The second shows a cross-section with approximately 24 m^2 of duct space, which satisfies the requirements of zones 2 and 4. However, this cross-section would also be constructed within ventilation zones 1 and 5 with additional separate and adjacent ventilation adits to make up the 24 m^2 shortfall in duct space. Figure 4.19 shows the conceptual cross-section for the rail tunnel.

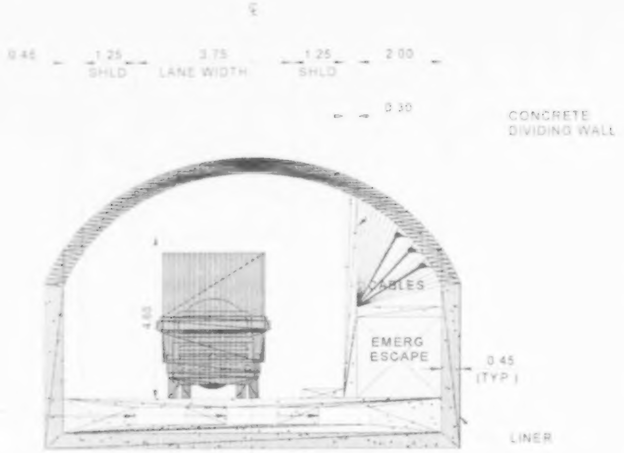

℄
0.45
1.25
SHLD
3.75
LANE WIDTH
1.25
SHLD
2.00
0.30
CONCRETE
DIVIDING WALL
4.65
CABLES
EMERG
ESCAPE
0.45
(TYP.)
LINER

Figure 4.17 - Drill & Blast Road Tunnel Cross Section-Ventilation Zone 3

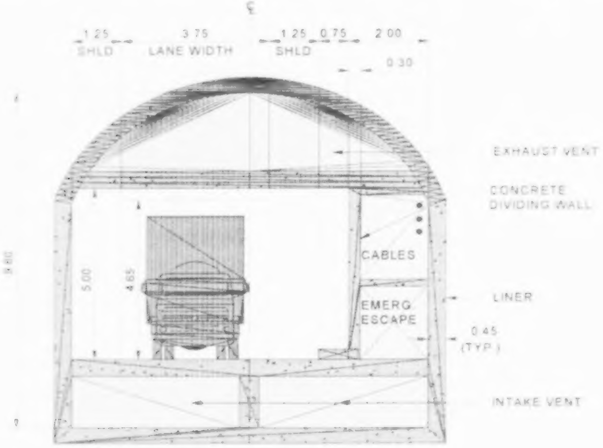

℄
1.25
SHLD
3.75
LANE WIDTH
1.25
SHLD
0.75
2.00
0.30
EXHAUST VENT
CONCRETE
DIVIDING WALL
5.00
4.65
CABLES
LINER
EMERG
ESCAPE
0.45
(TYP.)
INTAKE VENT

Figure 4.18 - Drill & Blast Road Tunnel Cross-section -Ventilation Zones 1, 2, 4, and 5

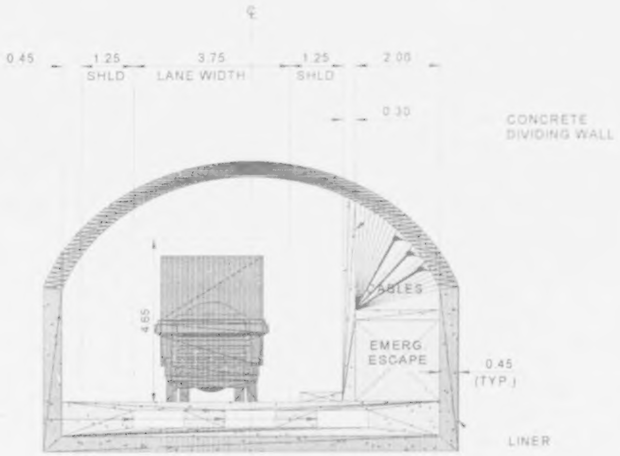

℄
0.45
1.25
SHLD
3.75
LANE WIDTH
1.25
SHLD
2.00
0.30
CONCRETE
DIVIDING WALL
4.65
CABLES
EMERG.
ESCAPE
0.45
(TYP.)
LINER

Figure 4.17 - Drill & Blast Road Tunnel Cross Section-Ventilation Zone 3

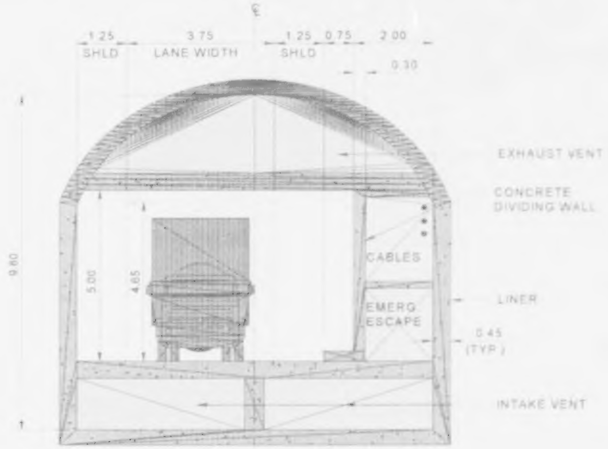

℄
1.25
SHLD
3.75
LANE WIDTH
1.25
SHLD
0.75
2.00
0.30
EXHAUST VENT
CONCRETE
DIVIDING WALL
9.60
5.00
4.65
CABLES
LINER
EMERG.
ESCAPE
0.45
(TYP.)
INTAKE VENT

Figure 4.18 - Drill & Blast Road Tunnel Cross-section -Ventilation Zones 1, 2, 4, and 5

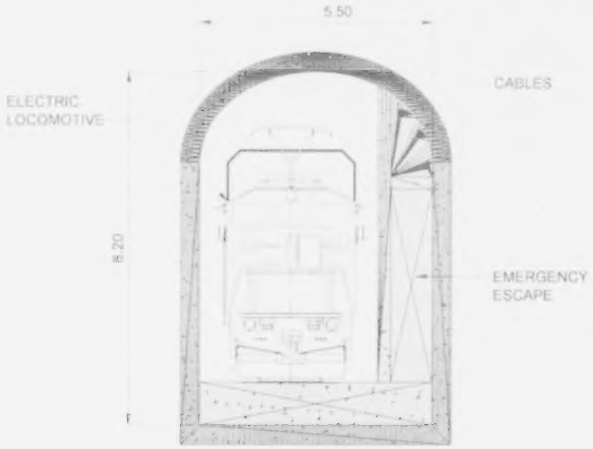


Figure 4.19 - Drill and Blast Rail Tunnel Cross-section

Capital Cost Estimate

The principal assumptions used in preparation of the drill & blast tunnelling estimates are as follows:

Tunnel driven from both sides of the Strait simultaneously

Labour conditions and wages as outlined in the Newfoundland labour agreement 2003, as noted previously

Average drill & blast advance rate of 3.2 metres per day and 3.0 metres per day for road and rail tunnels respectively

40% of tunnel length requires crown rockbolts and wiremesh only for primary support

50% of tunnel length requires full pattern rockbolts, wiremesh, and 50mm thickness of shotcrete for primary support

10% of tunnel length requires steel sets and 100 mm thickness of shotcrete for primary support

10% of tunnel requires grouting

Cast-in-place final liner installed in tunnel on completion of drill & blast operations

100% probing ahead

40% contingency applied to civil elements of the work

20% contingency applied to mechanical and electrical elements of the work

15% Contractor's overheads and profit applied

17% applied to the overall estimate for design, construction management and owner's costs

$15 million allowed for feasibility study and environmental assessment

For tunnelling projects, it is typical for contingencies at a pre-feasibility stage to range from 40% to 75%. The selection of contingency level is particularly related to the existance or lack of geotechnical investigation. Typically at this stage no investigation has taken place. For this project, a contingency of 40% has been chosen for the tunnel (civil) costs since a conceptual geotechnical investigation has taken place, several years earlier, and therefore the lower end of the range of contingency levels can be used.

The construction cost of the road tunnel option is estimated to be $1,800 million in 2004 dollars. This figure includes ventilation equipment, lighting, sumps and pumping, tunnel approaches, and vehicle waiting areas on both sides of the Strait. The cost of the rail tunnel is estimated to be $2,272 million in 2004 dollars. This figure includes the full cost of the electric rail shuttle system in addition to the other items. A detailed cost breakdown for both options is provided in Appendix D.

Schedule

The schedule for drill and blast construction is based on a typical advance rate for this type of constuction and for the fact that this method will be greatly affected by the need to reduce water inflows during construction. For long tunnels, it is now typical that drill and blast techniques are not used because of their very slow progress rate compared to tunnel boring machines.

The drill & blast tunnelling operations would be undertaken from both sides of the Strait. The schedule for the road tunnel as shown in Figure 4.20 is 214 months from project commencement, assuming 24 months for tunnel design. The schedule for the rail option is 286 months because of the additional length.

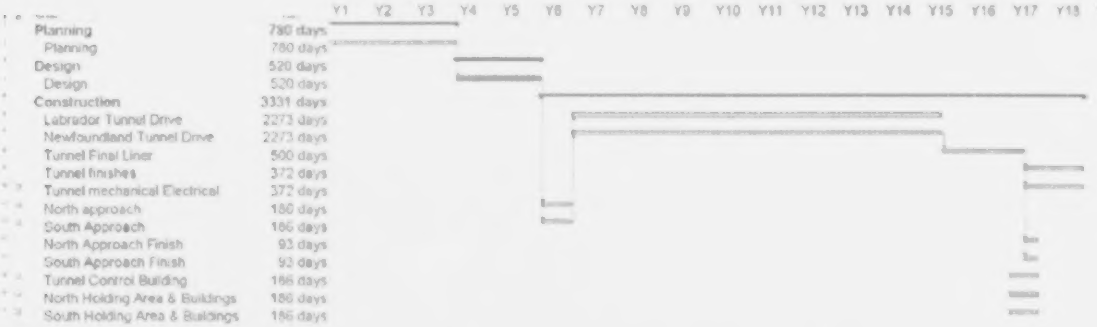


Figure 4.20 - Drill & Blast Road Tunnel Schedule

4.3.3 Immersed Tube Tunnel (ITT)

An ITT can be simply described as a series of connected and sealed pre-fabricated tunnel units within a pre-dredged trench in the seabed. The tunnel units are floated to their required location and sunk to their final position, an operation which requires a great deal of care and precision. Special seals are used between adjacent tunnel units to ensure construction of a watertight tunnel. Once the tunnel units are in position, the trench is backfilled to form the ITT. Three main alternatives exist for construction of an ITT:

- *Reinforced Concrete Tunnel Construction* – rectangular shaped reinforced concrete units
- *Steel Shell Tunnel Construction* – cylindrical steel shell units
- *Composite (SCS)* – approximately rectangular steel units with concrete on the inside

Each of these methods has distinct advantages and disadvantages in relation to the other, and for details of these the reader is referred to the detailed description of the ITT option provided in Appendix C. For current conceptual cost estimating and scheduling purposes, it has been assumed that reinforced concrete tunnel construction is the optimum means of undertaking the work largely because the construction industry in Newfoundland is likely to be most suited to this type of ITT unit construction. Several locations in the Province should be suitable for such fabrication including those that have been used in the offshore oil industry. It is also possible that a new site could be developed close to the tunnel construction sites to minimize towing distance. To create a suitable site, a small inlet could be dammed off to create a dry dock (similar to Bull Arm/Great Mosquito Cove but on a smaller scale). Ultimately such a decision would rest with the contractor.

As noted in the discussion of other link concepts, there are very significant risks associated with the construction of an ITT in the Strait of Belle Isle. The concept has similar risks to those discussed for the bridge and causeway concepts in that the construction would be in a hostile environment in deep water containing sea ice and icebergs. In addition, in the case of an ITT, there are construction risks associated with the excavation in bedrock in deep water (in the case of placing the ITT in a deep trench to avoid iceberg scour) at large water depths. Furthermore, there is the risk associated with the design of the depth of burial in overburden to avoid scour or the design of sufficient protection works to absorb iceberg impact if the ITT is not buried in a ditch.

Although many comparable studies for ITT crossings with similar complexities have been conducted in the recent past – such as a 19 kilometres long ITT alternative for the crossing of the English Channel and an 85 kilometre long crossing of the Bering Strait, the construction of an ITT of the magnitude of the proposed crossing has never been attempted. At present, the world's longest immersed tube tunnel is the Bay Area Rapid Transit Tunnel in Oakland, California, which is 5.8 kilometres long in a maximum water depth of 40.5 metres and which opened in 1970. In the relatively near future, a deeper ITT will be constructed across the Bosphorus Channel although at 60 metres the depth of this crossing will not approach the depths required for an ITT crossing of the Strait of Belle Isle.

Section 3 of this report described the surficial and bedrock geology for the proposed crossing between Pointe Amour and Yankee Point. Borings from the 1981 drilling program indicate that the seabed overburden consists of thin deposits of shells, sand, gravel, glaciomarine marine deposits and dense till. Along the proposed route, the average overburden thickness, including till, is 2.5 to 3.0 metres. Two of the borings, A1 and B4, did not however reach the bedrock and encountered either the glaciomarine marine deposits or tills to full depth. The maximum thickness of these surficial deposits is not known and estimates vary depending upon the source. It does however seem likely that depths will exceed 5 metres, and perhaps reach 10-12 metres in localized depressions. The maximum drilled depth to bedrock below the seabed in this investigation was 3.69 metres with an average depth of 2.5 metres. The bedrock consisted primarily of limestone and shale, with some sandstone, and is generally described as dense and fresh.

Based on the soil test results provided from these borings, the slope angles shown in Table 4.1 were adopted for the purposes of estimating the cost of ITT construction.

Table 4.1: Estimated Stable Slope Angles for the Soil and Rock Strata

Overburden unit/Bedrock Formation	Estimated Slope angle for a stable slope based on an submerged infinite slope analysis
Sand, Shells & Gravel	1 vertical to 2 horizontal
Glaciomarine – Marine Deposits	1 vertical to 4 horizontal
Glacial Till	1 vertical to 3 horizontal
Sedimentary Rock Strata	5 vertical to 1 horizontal

Figures 4.21 and 4.22 show conceptual profiles for road and rail ITT options respectively. Both profiles assume that the ITT is located within a pre-excavated trench in the seabed with 6% approach grades for the road tunnel and 1.8 % grades for the rail tunnel. The trench in bedrock is excavated to a depth nominally greater than the height of the ITT unit since scour in bedrock is not a factor, and to a depth of approximately 14 metres in overburden to allow for 5.5 metres of material on top of the units to accommodate iceberg scour.

For excavation of the ITT trench, it is anticipated that the soft ground overburden will be removed using clamshell or hydraulic equipment without need for pre-treatment. Up to depths of about 40 m, normal clamshell grabs will be suitable, while remotely operated vessel (ROV) steered clamshell grabs will be required elsewhere. Such ROV's have been successfully used in water depths exceeding 100 metres but not for this purpose.

Excavation of the underlying limestone and sandstone layers is likely to be more problematic and blasting or submersible excavation equipment may be required. Blasting in water depths of 100 metres is rare; in recent years tracked land-based construction machines have been developed to operate in water depths of over 100 m. Such machines are likely to be necessary for deeper sections of the ITT alignment.

The presence of sea ice will have a significant effect on dredging operations, and it is anticipated that dredging will only be possible for about 7 months of the year. It is also probable that redredging of the trench will be required prior to placement of the tunnel units, as previous investigations suggest that the bottom currents are capable of moving sediments. For cost estimating purposes, an allowance of 15% of the original total excavation has been assumed.

ITT construction techniques would be used only for undersea sections of the alignment, and more conventional open cut, drill & blast tunnelling, or TBM bored tunnelling would be employed for underland sections of the alignment. Specialized construction methods are required at the land/sea interface zones to prevent flooding of the immersed tube. These methods will vary from location to location, depending on seabed depths and profiles and the construction methods adopted for the landward sections.

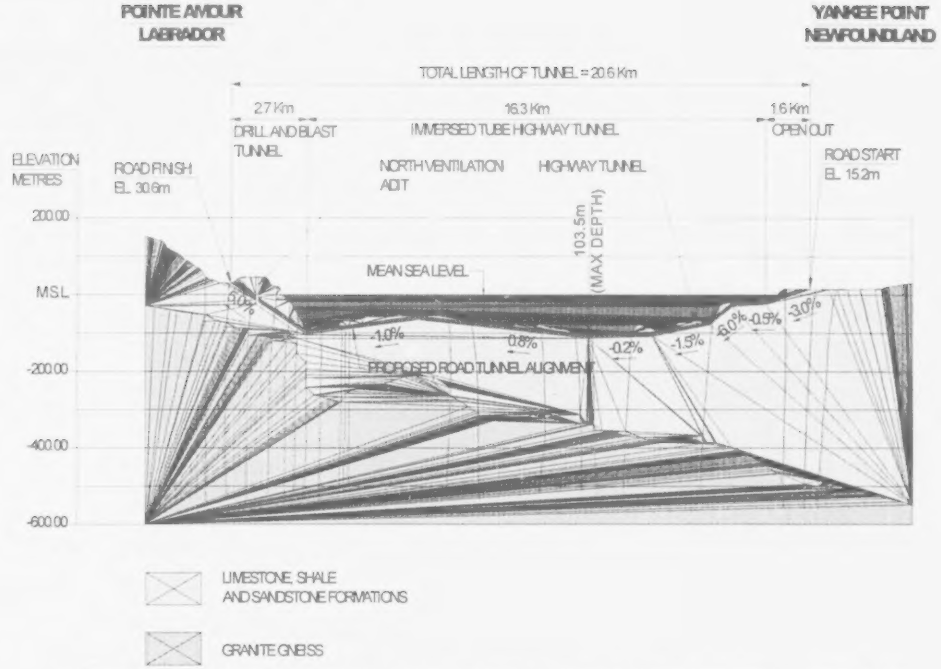

POINTE AMOUR
LABRADOR
YANKEE POINT
NEWFOUNDLAND
TOTAL LENGTH OF TUNNEL = 20.6 Km
2.7 Km
DRILL AND BLAST
TUNNEL
16.3 Km
IMMERSED TUBE HIGHWAY TUNNEL
1.6 Km
OPEN CUT
ELEVATION
METRES
ROAD FINISH
EL. 30.6m
NORTH VENTILATION
ADIT
HIGHWAY TUNNEL
ROAD START
EL. 15.2m
103.5m
(MAX DEPTH)
200.00
MEAN SEA LEVEL
M.S.L.
-200.00
-400.00
-600.00
6.0%
-1.0%
0.8%
-0.2%
-1.5%
6.0%
-0.5%
3.0%
PROPOSED ROAD TUNNEL ALIGNMENT
LIMESTONE, SHALE
AND SANDSTONE FORMATIONS
GRANITE GNEISS

Figure 4.21 - Immersed Tube Road Tunnel Conceptual Profile

Based on the soil test results provided from these borings, the slope angles shown in Table 4.1 were adopted for the purposes of estimating the cost of ITT construction.

`Table 4.1: Estimated Stable Slope Angles for the Soil and Rock Strata`

Overburden unit/Bedrock Formation	**Estimated Slope angle for a stable slope based on an submerged infinite slope analysis**
Sand, Shells & Gravel	1 vertical to 2 horizontal
Glaciomarine – Marine Deposits	1 vertical to 4 horizontal
Glacial Till	1 vertical to 3 horizontal
Sedimentary Rock Strata	5 vertical to 1 horizontal

Figures 4.21 and 4.22 show conceptual profiles for road and rail ITT options respectively. Both profiles assume that the ITT is located within a pre-excavated trench in the seabed with 6% approach grades for the road tunnel and 1.8 % grades for the rail tunnel. The trench in bedrock is excavated to a depth nominally greater than the height of the ITT unit since scour in bedrock is not a factor, and to a depth of approximately 14 metres in overburden to allow for 5.5 metres of material on top of the units to accommodate iceberg scour.

For excavation of the ITT trench, it is anticipated that the soft ground overburden will be removed using clamshell or hydraulic equipment without need for pre-treatment. Up to depths of about 40 m, normal clamshell grabs will be suitable, while remotely operated vessel (ROV) steered clamshell grabs will be required elsewhere. Such ROV's have been successfully used in water depths exceeding 100 metres but not for this purpose.

Excavation of the underlying limestone and sandstone layers is likely to be more problematic and blasting or submersible excavation equipment may be required. Blasting in water depths of 100 metres is rare; in recent years tracked land-based construction machines have been developed to operate in water depths of over 100 m. Such machines are likely to be necessary for deeper sections of the ITT alignment.

The presence of sea ice will have a significant effect on dredging operations, and it is anticipated that dredging will only be possible for about 7 months of the year. It is also probable that redredging of the trench will be required prior to placement of the tunnel units, as previous investigations suggest that the bottom currents are capable of moving sediments. For cost estimating purposes, an allowance of 15% of the original total excavation has been assumed.

ITT construction techniques would be used only for undersea sections of the alignment, and more conventional open cut, drill & blast tunnelling, or TBM bored tunnelling would be employed for underland sections of the alignment. Specialized construction methods are required at the land/sea interface zones to prevent flooding of the immersed tube. These methods will vary from location to location, depending on seabed depths and profiles and the construction methods adopted for the landward sections.

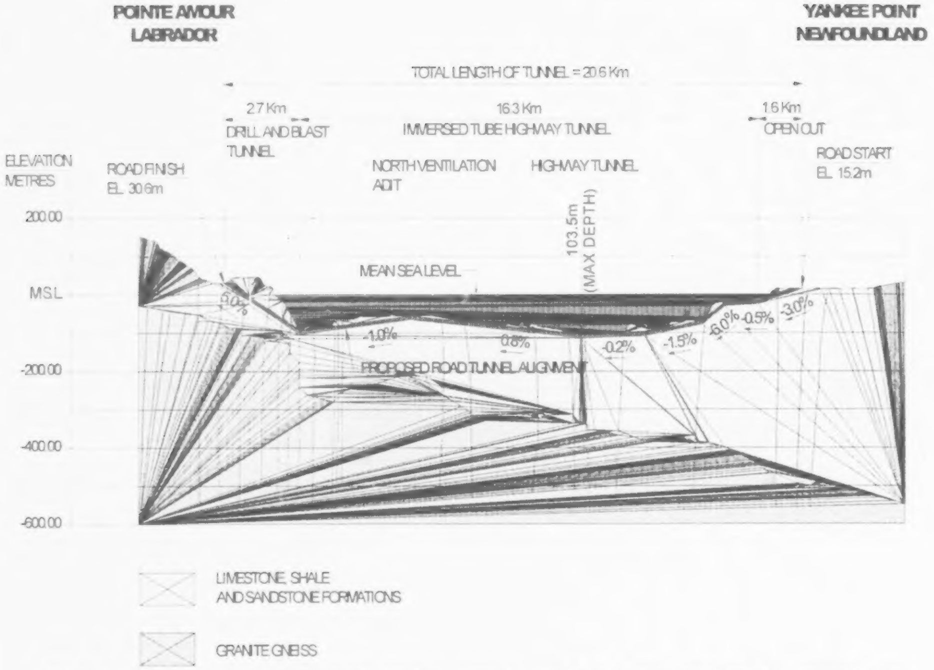

POINTE AMOUR
LABRADOR
YANKEE POINT
NEWFOUNDLAND
TOTAL LENGTH OF TUNNEL = 20.6 Km
2.7 Km
DRILL AND BLAST
TUNNEL
16.3 Km
IMMERSED TUBE HIGHWAY TUNNEL
1.6 Km
OPEN CUT
ELEVATION
METRES
ROAD FINISH
EL. 30.6m
NORTH VENTILATION
ADIT
HIGHWAY TUNNEL
ROAD START
EL. 15.2m
103.5m
(MAX DEPTH)
200.00
MEAN SEA LEVEL
MSL
5.0%
-1.0%
0.8%
-0.2%
-1.5%
6.0%
-0.5%
3.0%
PROPOSED ROAD TUNNEL ALIGNMENT
-200.00
-400.00
-600.00
LIMESTONE, SHALE
AND SANDSTONE FORMATIONS
GRANITE GNEISS

Figure 4.21 - Immersed Tube Road Tunnel Conceptual Profile

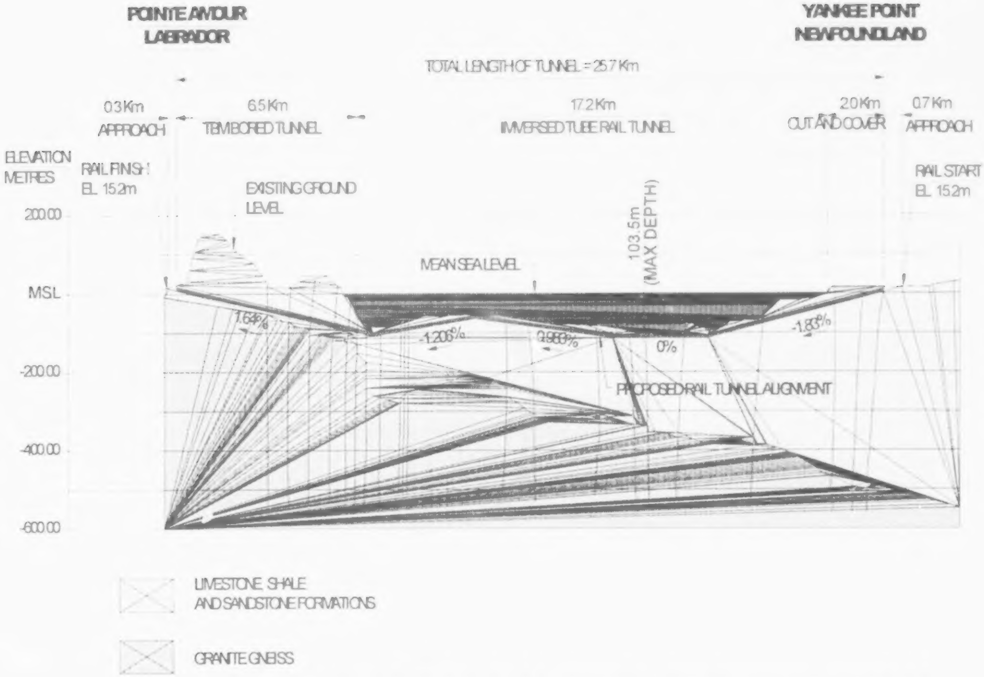

POINTE AMOUR
LABRADOR
YANKEE POINT
NEWFOUNDLAND
TOTAL LENGTH OF TUNNEL = 25.7 Km
0.3Km
APPROACH
6.5Km
TBM BORED TUNNEL
17.2Km
IMMERSED TUBE RAIL TUNNEL
2.0Km
CUT AND COVER
0.7Km
APPROACH
ELEVATION
METRES
RAIL FINISH
EL 15.2m
EXISTING GROUND
LEVEL
103.5m
(MAX DEPTH)
RAIL START
EL 15.2m
200.00
MEAN SEA LEVEL
MSL
1.64%
-1.206%
0.988%
0%
-1.83%
-200.00
PROPOSED RAIL TUNNEL ALIGNMENT
-400.00
-600.00
LIMESTONE, SHALE
AND SANDSTONE FORMATIONS
GRANITE GNEISS

Figure 4.22 - Immersed Tube Rail Tunnel Conceptual Profile

Three cross-sections reflecting different ventilation zones for the road ITT are shown in Figures 4.23, 4.24 and 4.25 and a single section for the rail ITT is shown in Figure 4.26.

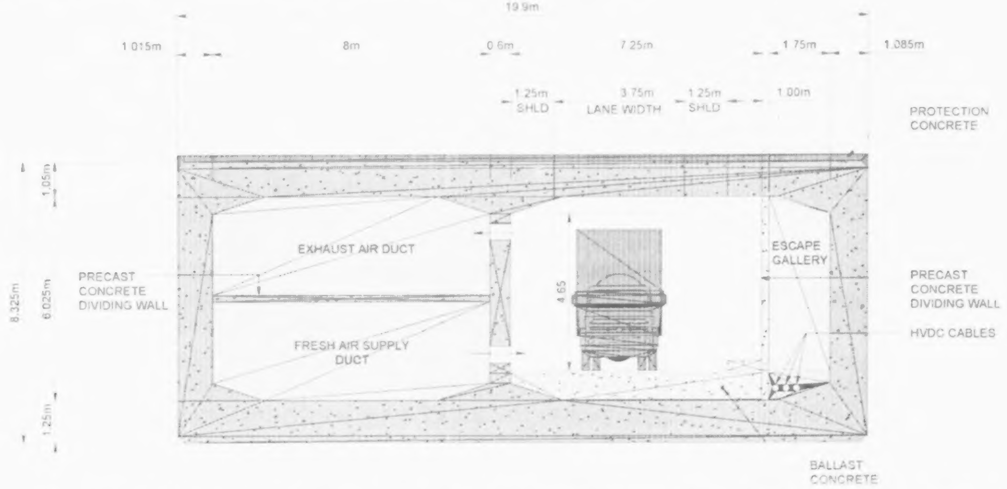

19.9m
1.015m
8m
0.6m
7.25m
1.75m
1.085m
1.25m
SHLD
3.75m
LANE WIDTH
1.25m
SHLD
1.00m
PROTECTION
CONCRETE
1.05m
EXHAUST AIR DUCT
ESCAPE
GALLERY
PRECAST
CONCRETE
DIVIDING WALL
8.325m
6.025m
4.65
PRECAST
CONCRETE
DIVIDING WALL
HVDC CABLES
FRESH AIR SUPPLY
DUCT
1.25m
BALLAST
CONCRETE

Figure 4.23 - ITT Road Tunnel Cross-section for Ventilation Zone 1

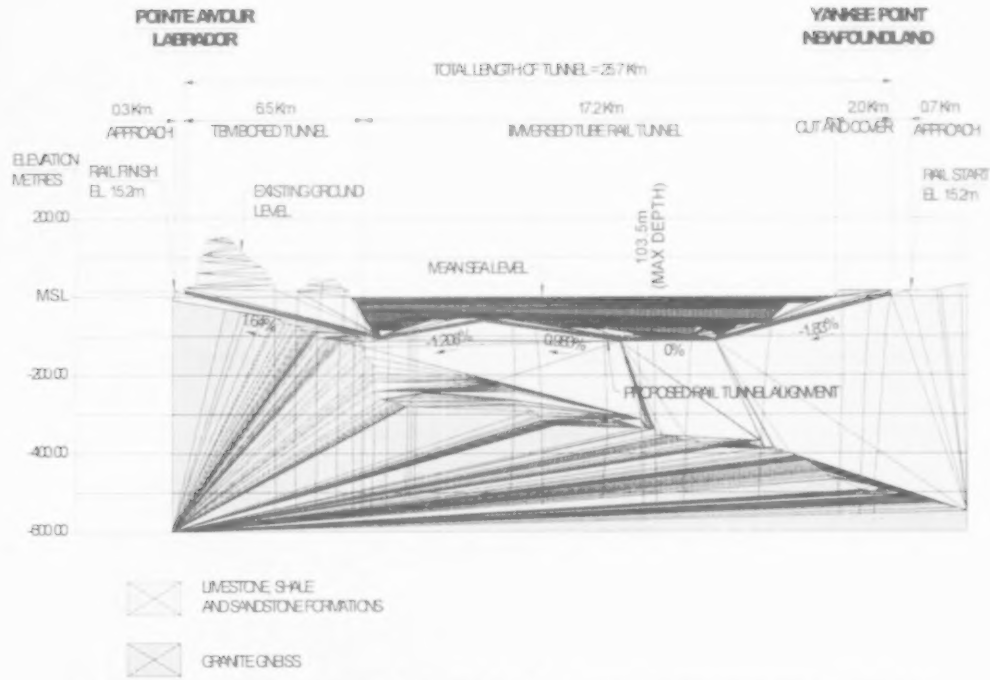

POINTE AMOUR
LABRADOR
YANKEE POINT
NEWFOUNDLAND
TOTAL LENGTH OF TUNNEL = 25.7 Km
0.3Km
APPROACH
6.5Km
TBM BORED TUNNEL
17.2Km
IMMERSED TUBE RAIL TUNNEL
2.0Km
CUT AND COVER
0.7Km
APPROACH
ELEVATION
METRES
RAIL FINISH
EL 15.2m
EXISTING GROUND
LEVEL
103.5m
(MAX DEPTH)
RAIL START
EL 15.2m
200.00
MEAN SEA LEVEL
MSL
1.6%
-1.20%
0.98%
0%
-1.8%
-200.00
PROPOSED RAIL TUNNEL ALIGNMENT
-400.00
-600.00
LIMESTONE, SHALE
AND SANDSTONE FORMATIONS
GRANITE GNEISS

Figure 4.22 - Immersed Tube Rail Tunnel Conceptual Profile

Three cross-sections reflecting different ventilation zones for the road ITT are shown in Figures 4.23, 4.24 and 4.25 and a single section for the rail ITT is shown in Figure 4.26.

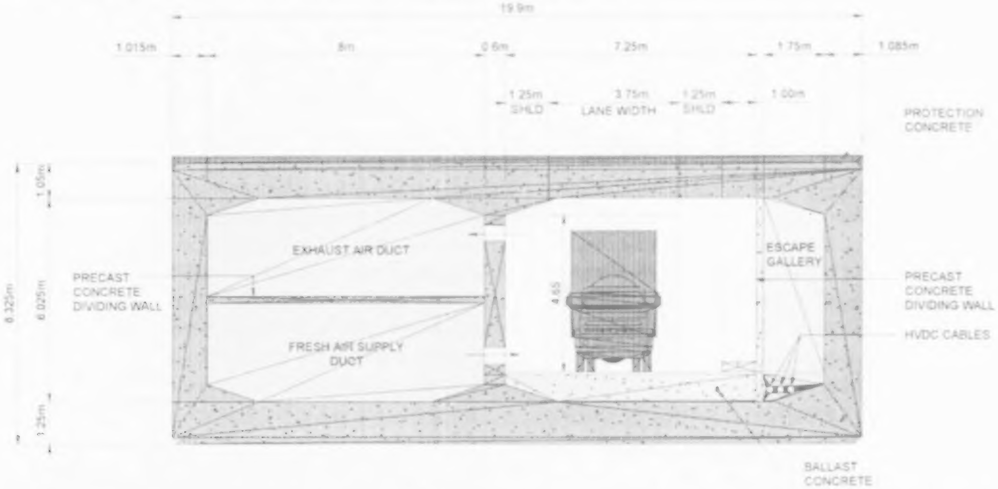

19.9m
1.015m
8m
0.6m
7.25m
1.75m
1.085m
1.25m
SHLD
3.75m
LANE WIDTH
1.25m
SHLD
1.00m
PROTECTION
CONCRETE
1.05m
EXHAUST AIR DUCT
ESCAPE
GALLERY
PRECAST
CONCRETE
DIVIDING WALL
6.325m
6.025m
4.65
PRECAST
CONCRETE
DIVIDING WALL
FRESH AIR SUPPLY
DUCT
HVDC CABLES
1.25m
BALLAST
CONCRETE

Figure 4.23 - ITT Road Tunnel Cross-section for Ventilation Zone 1

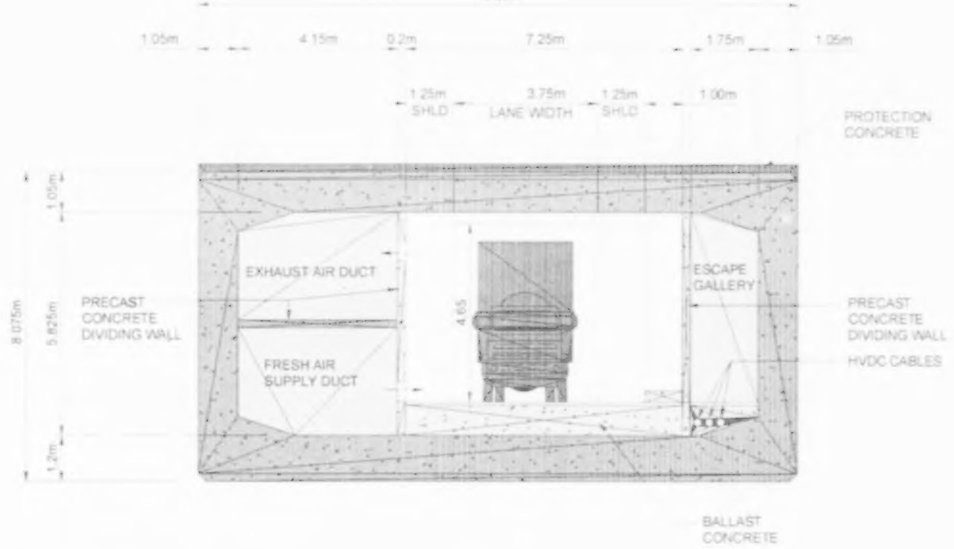

15.55m
1.05m
4.15m
0.2m
7.25m
1.75m
1.05m
1.25m SHLD
3.75m LANE WIDTH
1.25m SHLD
1.00m
PROTECTION CONCRETE
1.05m
8.075m
5.825m
1.2m
PRECAST CONCRETE DIVIDING WALL
EXHAUST AIR DUCT
FRESH AIR SUPPLY DUCT
4.65
ESCAPE GALLERY
PRECAST CONCRETE DIVIDING WALL
HVDC CABLES
BALLAST CONCRETE

Figure 4.24 - ITT Road Tunnel Cross-section for Ventilation Zone 2

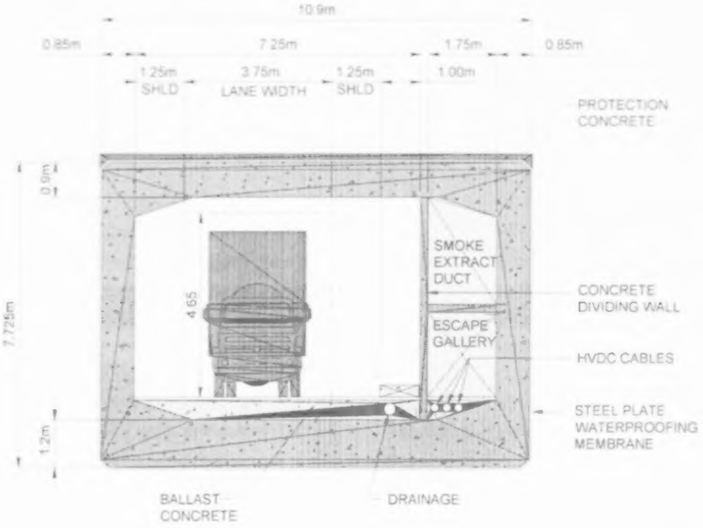

10.9m
0.85m
7.25m
1.75m
0.85m
1.25m SHLD
3.75m LANE WIDTH
1.25m SHLD
1.00m
PROTECTION CONCRETE
0.9m
7.725m
1.2m
4.65
SMOKE EXTRACT DUCT
ESCAPE GALLERY
CONCRETE DIVIDING WALL
HVDC CABLES
STEEL PLATE WATERPROOFING MEMBRANE
BALLAST CONCRETE
DRAINAGE

Figure 4.25 - ITT Road Tunnel Cross-section for Ventilation Zone 3

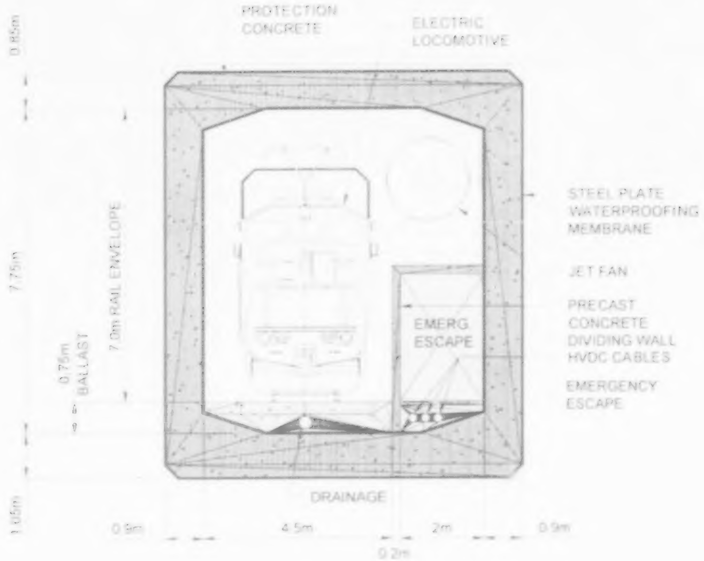

PROTECTION
CONCRETE
ELECTRIC
LOCOMOTIVE
STEEL PLATE
WATERPROOFING
MEMBRANE
JET FAN
PRECAST
CONCRETE
DIVIDING WALL
HVDC CABLES
EMERGENCY
ESCAPE
EMERG
ESCAPE
DRAINAGE
0.85m
7.75m
1.05m
7.0m RAIL ENVELOPE
0.75m
BALLAST
0.9m
4.5m
2m
0.9m
0.2m

Figure 4.26 - ITT Rail Tunnel Cross-section

[illegible]

In developing the cost estimate, multiple sources of information have been used including:

- Bull Arm Site Corporation for lease costs for drydock, batching plant, reinforcement shop and the deep-water storage site.
- Newfoundland Heavy Construction Cost database for principal quantities including cast-in-place and precast concrete, formwork, reinforcement, structural steel, surfacing etc.
- historic information for tunnel joint prices for the special seals between ITT units, escalated to 2004 prices, with applied contingency for anticipated larger seal requirements.
- rates for dredging, and backfilling for the tunnel based upon discussions with multiple dredging contractors.
- remobilization costs which will be incurred each dredging season due to sea ice induced shutdown

As stated earlier, the costs of the ITT have been developed based on the use of concrete tunnel technology. To derive basic tunnel quantities, in conjunction with the proposed traffic clearance envelopes and stipulated ventilation requirements, minimum factors of safety for the ITT sections while afloat and in-place were assumed, which allowed the development of concrete member sizes. The only figure which has been specifically modified for this project is that of reinforcement. Concrete ITT's at normal depth will typically have a reinforcement density in the region of 110 kg/m^3. For cost estimating purposes, far higher reinforcement densities have been assumed, to reflect the higher imposed loadings due to the deeper submergence in the present case.

For the dredged trench, representative sections were developed, with variations in the depth of the overburden or surficial deposits, which as mentioned, have an average thickness of between 2.5 and 3 m. The deposits themselves vary from the relatively weak and unstable glaciomarine - marine deposits to the much more stable sands, gravels, and tills. Correspondingly, the weaker soils will be cut back at shallower angles to maintain trench stability.

Sections were developed for each of the tunnel geometry options, providing high-end and low-end dredge quantities by varying the overburden geology and thickness. Side slope angles were in accordance with the recommendations made previously. The two extreme values were averaged to obtain the quantity estimate. At the same time this approach provided an indication of the influence that overburden variations could have on the quantities and hence costs. It is conceivable that within a certain area, the cross-sectional area of the trench could be significantly higher or lower than predicted. However until the surficial deposits are investigated further, and their limits more accurately defined, this "averaging" approach is considered the most appropriate.

An alternative to constructing an immersed tube tunnel (ITT) in a ditch of sufficient depth to avoid iceberg scour is to lay it on the prepared seabed with minimal excavation and protect it from icebergs by using a rock protection berm, which would be sufficiently robust to absorb iceberg impact, in a manner similar to the causeway concept. There is a level of risk associated with such a concept both in the construction and operational phases. During construction, the risk would be to cost relating to schedule delays, whereas during operation, there could be a human as well as a financial risk. These types of risks may be minimized to an acceptable level by implementing an iceberg management program as referred to previously. During construction, icebergs could be towed or construction halted until the hazard has passed. During operation, the tunnel could be temporarily closed if the hazard is deemed high enough.

The interaction dynamics of an iceberg with a rock berm and the subsequent mechanism through which the energy of the iceberg is dissipated are speculative, in the absence of any actual observations, modeling or detailed analytical assessments. For the purposes of the current exercise, however, some reasonable assumptions of these processes may be made. The energy of the iceberg would be dissipated through contact with, and possible displacement of, rock elements, compression of the rockfill, crushing of the iceberg over the contact area, or a combination of these processes. There is also some evidence to suggest that, given a sufficiently shallow slope, the iceberg may ride up or roll over the berm. While a shallow slope is desirable in terms of slowing the iceberg with little or no penetration into the berm, it does present the possibility that through rolling, the iceberg may exert loads on the top of the immersed tube from transmission of forces through the rockfill on top of the tunnel. Such a possibility determines the depth and characteristics of the protection works on top of the tunnel.

For present purposes to provide a rough estimate of the cost of protection, the depth of the rock cover over the railway tunnel is assumed to be 4 metres and the slope is 1:5 to encourage loss of energy due to sliding contact. It is unlikely that the depth of cover would be any less than this, and therefore the associated costs may be considered a minimum for this depth and slope. The resulting volume of rock in the berm is 17.38 million m^3 and the cost at \$100 per m^3 in place (for nominal 1 metre stone) would be \$1738 million. If subsequent analysis showed that the slope could be increased to 1:1.8 (similar to that used in the causeway rockfill berms) without undue loads being exerted on the tunnel, the cost for protection would be reduced to \$665 million, which is still more expensive than the dredging and backfilling costs of \$430 million required to locate the railway ITT within an excavated trench without a protective berm.

The construction cost of the road ITT option is estimated to be $4,810 million in 2004 dollars. This figure includes ventilation equipment, lighting, sumps and pumping, tunnel approaches, and vehicle waiting areas on either side of the Strait. The construction cost of the rail ITT is estimated to be $2,814 million. This figure also includes cost of the electric rail shuttle system. A detailed breakdown of the estimates for both options is provided in Appendix D.

Principal assumptions used in preparation of the above estimates are as follows:

- 40% contingency applied to civil elements of the work
- 20% contingency applied to mechancial and electrical elements of the work
- 15% contractor's overheads and profits applied to the estimate
- $15 million for feasibility study and environmental assessment
- 17% for engineering and project management

Schedule

The major critical path items for the development of a schedule for the ITT construction are:

- Dredging of the trench
- Fabrication of the tunnel elements
- Placement of the tunnel elements

The tunnel placement operation has been used as the basis for deriving the tunnel construction duration. The Strait is accessible in the months of June to December, typically comprising a period of approximately 30 weeks. It has been assumed that in these months, tunnel elements will be placed approximately at the rate of one per week. However, provision should be made within this schedule for factors such as the required tow length from identified facilities, inclement weather, including prolonged winter, and icebergs. For these reasons we have assumed that 25 elements will be placed per season. This remains a demanding figure for one season of sonstruction.

Other assumptions include:

Sufficient dredging must be performed each season to accommodate placement of 25 elements. The dredging operation will be continuous, 24 hours per day, 7 days per week. It is also assumed that multiple dredgers will be in operation at any given time.

Similarly, suitable fabrication facilities can be leased or constructed, and sufficient skilled labor can be identified to accommodate the construction of 25 elements per year. Due to the size of the project, the potential exists for more than one fabrication facility to be engaged. It is assumed that sufficient facilities can be available to meet the recommended production requirement.

A tunnel element length of 150 metres has been assumed. This is longer than average, but within current technological limits. The longest concrete elements to date, for the Oresund Tunnel, measured 175 m, and the longest steel plated elements measured 135 metres approximately. The 150-m length is a usable figure on the basis that further study would be necessary to fully define a preferred construction method.

It is assumed that Newfoundland will provide the majority of the fabrication facilities, and will be the primary source of labour for the project. Therefore, it is assumed that the construction of the Newfoundland approach could proceed more rapidly, and be available sooner to interface with the ITT. Subsequently, placement of tunnel elements will proceed from the Newfoundland side, enabling internal concrete works to begin from this location.

Internal fitting-out of the tunnel can continue year-round providing that three bulkheads are maintained between this work and newly installed units.

Internal concreting of the tunnel sections, including emergency corridor, and roadway ballast or track slab, will proceed after placement of several elements.

Figure 4.27 provides a schedule for construction of the road ITT option. The estimated duration from project commencement is 176 months, assuming 36 months for planning activities and 24 months for tunnel design. The schedule for construction of the rail option is similar but 4 months longer.

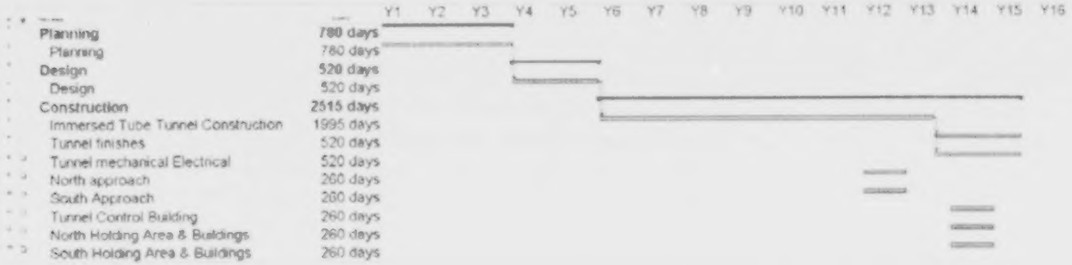


Figure 4.27 - Road ITT Schedule

4.4 Comparison of Alternatives

Risk Assessment

In comparing the link alternatives it is important to address the risks associated with them. These risks can be divided into two major categories; short term risks associated with the construction and long term risks related to the operation of the facility. These risks have been already referred to in the respective descriptions of the alternatives and are, for the most part, repeated here for the sake of completeness.

Construction Risks

Bridge

For the bridge construction several conditions at the site present unusual levels of risk. Included in these would be:

- Heavily travelled navigation channel
- Icebergs

- Difficult sea ice conditions during the winter period that would likely prevent marine based construction during this period
- Significant water depths, approaching 100 m, with potentially heavy seas and strong currents presenting difficulties in constructing foundations for piers and placing protection works.

These risks, combined, present a high level of risk that the construction would be interrupted and the schedule extended with consequent increases in cost.

Causeway

The causeway, being constructed within the marine environment is exposed to the same conditions as the bridge. The causeway itself would be less sensitive to these conditions but the bridge component would have the same problems as the all-bridge concept. Overall, this concept would have a lower level of construction risk than the all-bridge concept.

Bored Tunnel

The bored tunnel constructed by tunnel boring machine is not exposed to the hostile environmental conditions facing the bridge and causeway options. The construction risks for this option relate to the inherent risks associated with tunnelling. These risks are related to geotechnical conditions, particularly to the presence of faults or fractured rock requiring immediate support and to the presence of water inflows.

The selection of an earth pressure balance tunnel boring machine together with a precast concrete tunnel lining substantially reduces the risks presented by the geotechnical conditions. This type of machine seals off the workers from exposure to the ground conditions and to associated water inflows. The construction risks that remain relate to the appropriate operation of the machine and to its maintenance. For the operation, there are many ways of monitoring machine functions to reduce the risk of incorrect operation including frequent and multiple measurements of face pressure, measurement of excavated quantities compared with theoretical and automatic monitoring of the lining grouting process. All these functions would be monitored underground and remotely. Machine maintenance probably presents the highest risk level for this option. For planned maintenance, particularly of the cutterhead, areas where good ground conditions are expected would be chosen. For unplanned maintenance, the TBM will have facilities to apply compression air pressure to the bulkhead chamber onto which workers can enter with the appropriate compression and decompression times. Therefore, for construction risks, the bored tunnel is considered to be moderate or low risk.

Drill-and-Blast Tunnel

For the drill and blast tunnel, the construction risks again relate to geotechnical conditions. This technique does not provide the ability to pressurize the excavation face and for this reason the tunnel alignment has been lowered to increase the separation from the seabed. This is likely to reduce the generalized water ingress but does increase the potential hydrostatic pressure that may be present if a fault extends to the seabed. The only tool available to address these risks is rock grouting. This is generally effective but has failed in some cases. Therefore, for construction, the drill-and-blast tunnel is considered to be high risk.

Immersed Tube Tunnel

For the immersed tube tunnel, the construction process is exposed to the same risks that have been identified for the bridge option. In fact, the construction process is likely more sensitive to the environmental conditions, and would be significantly lengthened by limitations in seasonal working. Significantly an ITT in this location would have some unprecedented aspects. These include depth of immersion, length of tunnel, excavation of rock at depth underwater, and substantial excavation volumes. Therefore during construction, the immersed tube tunnel is considered to be a high risk alternative.

Operational Risk

Bridge

The bridge option presents considerable risk to the operation of the facility during the winter. These risks relate to snow and icing coupled with high winds, and fog conditions. It is presumed that issues related to iceberg and sea ice will have been addressed within the design of protection measures; however, there is always some risks associated with the interaction of an iceberg with the protection works. Further risk is associated with the possibility of ship impact although this is likely to be low probability with modern navigation equipment. In total, the risk of having operational interruptions in the winter months is considered to be high.

Causeway

The causeway option is exposed to the same environmental risks for the bridge but may be marginally less sensitive to wind and icing. In total, the risk of having operational interruptions in the winter months is considered to be high.

Tunnel Options

In terms of operational risks, all tunnels are considered to be similar for most risks. The major risk of service interruption is associated with breakdowns or accidents within the tunnel. For the road tunnels, the cross section has been selected to allow a broken down vehicle to be passed by other vehicles. This, together with CCTV monitoring of the tunnel, should significantly reduce the risk of service interruptions due to breakdowns.

For more substantial accidents and fires, an emergency egress passage has been provided and a fire suppressor system will likely be included to protect the structure and to reduce the closure time. Although fires in tunnels tend to be dramatic, their frequency is low, particularly for rail tunnels. Therefore, in total, the risk of having operational interruptions in the tunnel options is considered to be low. For the ITT, there is a risk of iceberg impact which could lead to substantial protection work repairs or damage to the ITT element itself.

Comparison Summary

Tables 4.2 and 4.3 provide a comparative summary of the road and rail options, respectively. It is seen that the TBM rail tunnel has the lowest capital cost and lowest risk. The construction schedule is similar to the ITT schedule at 15 years; however, the ITT costs are more than three times as high. For the purpose of the economic and business case analysis, the TBM bored rail tunnel will therefore be carried forward.

Table 4.2 - Comparison of Fixed Link Road Options

Option	Construction Cost ($M-2004)	Annual Operating Cost ($M-2004)	Risk Level	Project Duration (years)
TBM Bored Tunnel	1,559	6.8	Moderate	12.2
Drill & Blast Tunnel	1,800	6.8	High	17.8
Immersed Tube Tunnel	4,810	6.8	High	14.7
Bridge	4,227	16.9	Extreme	15
Bridge / Causeway	10,123	4.3	High	18

Table 4.3 - Comparison of Fixed Link Rail Options

Option	Construction Cost ($M-2004)	Annual Operating Cost ($M-2004)	Risk Level	Project Duration (years)
TBM Bored Tunnel	1,144	7.64	Moderate	12.5
Drill & Blast Tunnel	2,272	7.64	High	23.8
Immersed Tube Tunnel	3,814	7.64	High	15

5 DEVELOPMENT OF THE PREFERRED ALTERNATIVE

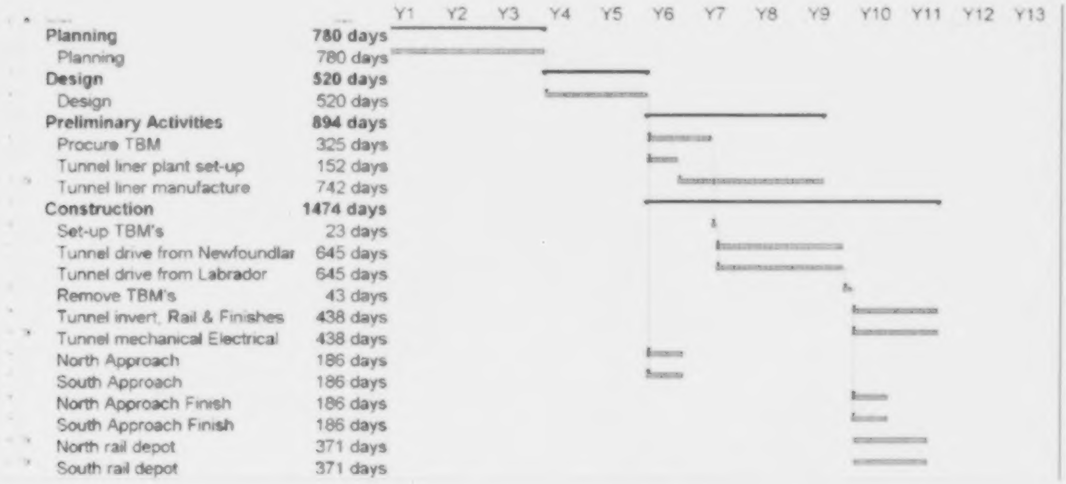
The previous section concluded that a TBM bored rail tunnel was the preferred alternative based on costs, risk and schedule. Further consideration is given here to improving the construction schedule and reducing costs.

5.1 Schedule

An option for reducing the construction duration was addressed. This was to change the work week from five to seven days and to use an additional TBM to allow concurrent tunnelling from both sides of the Strait.

The use of a second TBM will only be possible if sufficient power supply is available to serve the Labrador site. The TBM is likely to have a total connected power of about 4000 kW although the demand will be less than this. The recent introduction of variable frequency drives on TBMs may also reduce this requirement somewhat. In any event, power on the Labrador side would not be available under the current isolated grid arrangement. Thus a dedicated power plant would have to be provided by the construction contractor for this purpose unless additional power becomes available in the interim. This has been assumed in the cost estimate.

The resulting schedule is shown in Figure 5.1. The reduction in the schedule is 52 months from the previous 180 months. This assumes that 50% of the tunnelling work will be completed from Newfoundland and 50% from Labrador. This is unlikely to actually occur as one side will always advance farther than the other. This effect will likely offer some further schedule reduction but is beyond the level of detail required for this analysis. The reduction in the schedule, over one TBM, is 22 months.



Planning	**780 days**
Planning	780 days
Design	**520 days**
Design	520 days
Preliminary Activities	**894 days**
Procure TBM	325 days
Tunnel liner plant set-up	152 days
Tunnel liner manufacture	742 days
Construction	**1474 days**
Set-up TBM's	23 days
Tunnel drive from Newfoundlar	645 days
Tunnel drive from Labrador	645 days
Remove TBM's	43 days
Tunnel invert, Rail & Finishes	438 days
Tunnel mechanical Electrical	438 days
North Approach	186 days
South Approach	186 days
North Approach Finish	186 days
South Approach Finish	186 days
North rail depot	371 days
South rail depot	371 days

**Figure 5.1 Project Schedule for the Preferred Option
Using Seven Day Work Week & Two TBM's**

5.2 Cost Comparison

Table 5.1 provides the adjusted costs for the previously described option refinements.

Table 5.1 Costs for Preferred Option Refinements

Option	Construction Cost	Annual Operating Cost	Risk Level	Project Duration (Years)
1 TBM (5 day week)	1,144	7.64	Moderate	12.5 years
2 TBM's (7 day week)	1,184	7.64	Moderate	10.7 years

The overall development cost for the 2 TBM arrangement includes an allowance for the installation of HVDC cables, escalation, and IDC (Interest During Construction). Including the HVDC cable cost of $77 million brings the construction cost to $1261 million in 2004 dollars. In Section 8.2, escalation is shown to be $266 million and IDC, $258 million. The total development cost and the cost to finance is thus $1708 million.

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6 REGULATORY AND ENVIRONMENTAL ISSUES

A complete assessment of the environmental implications and requirements of a fixed link project would be undertaken as the project moves forward through its various stages. As the feasibility of the project is firmed up and at an appropriate time, formal documentation would be submitted by the project proponent to fulfill regulatory requirements. The outcome of this submission would determine the degree of environmental investigation and studies required for the project. The project would require federal and provincial approvals under the Canadian Environmental Assessment Act and the Newfoundland Environmental Act. Current practice does allow screening and registration under one jurisdiction with both levels of government acting as regulatory agencies jointly. A detailed list of the applicable legislation, standards and permits that would have to be obtained is included at the end of this discussion.

The documentation to be submitted would likely be substantial and in component parts to address the potential areas of interest and mitigation measures. The time frame for the overall process could be several years; for the purposes of developing preliminary schedules in this report, three years were assumed.

As part of the determination of final feasibility, a drilling program would be required to obtain better information on the geology of the bedrock that would be tunneled. Environmental approval would be required for this feasibility level activity before such a program could be carried out. A formal application process would be followed which would identify the various processes to be undertaken; regulators would then determine the degree of environmental assessment required before the drilling could proceed. Such an assessment may pertain to potential effects of the drilling on marine life, fishing activity and marine traffic.

At the current pre-feasibility level of study, some comments may be made on the potential environmental implications of constructing a tunnel under the Strait.

First of all, by building a tunnel, the effect on the environment, in particular the physical environment of the Strait, is minimized. There is no concern, obviously, for the potential large scale oceanographic and climatic effects that might be wrought by a surface crossing such as a causeway and bridge. In the location of the Strait itself, there would be no or very little effect from the actual tunneling process or from the traffic once the tunnel is completed. There may be some concern for the effect of noise on marine life during construction; there should be sufficient information from other marine tunneling projects to address any such concern. An occupational health and safety concern relates to the potential effects of the construction on the workers. Emissions from the mucking system operation would have to be controlled within certain limits for this purpose.

The principal concern with respect to the tunnel itself is likely the disposal of the excavated material. This would have to be transported to suitable disposal sites on both sides of the Strait if the tunnel is advanced from both ends. The volume of material on each side would be approximately 730,000 m^3. This is sufficient to cover an area of 7.3 hectares at a depth of 10 m. Material would have to be transported and disposed of in an environmentally acceptable manner at approved disposal sites. Consideration may have to be given to the sea water that would drain from the material over time. It is possible that some of the material could be used for road construction and general fill purposes in the approaches and terminus areas.

The other components of the project relate to the work required on both sides of the Strait to prepare the approaches and the facilities in the terminus areas. The construction associated with these activities is common to most road and buildings projects. Attention must be paid to the crossing of any stream with both appropriate design to accommodate fish flows and the implementation of procedures to prevent deleterious runoff during construction, the appropriate containment of fuels, and the transport and disposal of surface vegetation and any unsuitable excavated subsurface material. As far as is known, there are no rare species of plant or animal life or archaeological relics in the study areas, the general surrounding areas have been inhabited for a long time, and thus, there is not expected to be any unusual environmental effect resulting from such construction and operational activities in the study area.

Overall, while the project would be a major undertaking over a long construction period, its nature is such that there would not likely be major environmental concerns that are outside the realm of a more typical heavy construction and earth moving project.

6.1 List of Applicable Legislation, Standards, and Permits

Federal

Legislation

- The Canadian Environmental Assessment Act
- The Canadian Environmental Protection Act
- Fisheries Act
- The Navigable Waters Protection Act
- Fish Habitat, Authorization for Works or Undertakings Affecting Fish Habitat (HADD)
- Application for Construction within Navigable Waters
- Canada Labour Code
- Permit for Construction within Navigable Waters

Standards

- National Building Code of Canada (NBC)
- National Master Specification (NMS)
- International Organization for Standardization (ISO) Standard 9001 – Quality Systems
- Fire Commissioner of Canada Standards
- Applicable CAN/CSA standards
- NFC – National Fire Code
- National Plumbing Code
- Canadian Electrical Code
- National Energy Code of Canada
- Local Municipal Service Standards
- RTAC Road Design Manual

Provincial

Legislation

- Environmental Protection Act
- Water Resources Act
- Accessibility Act and Regulations
- Historic Resources Act
- Occupational Health and Safety Act
- Crown Lands Act
- Well Drilling Act
- Lands Act
- Forestry Act
- Wildlife Act
- Waste Material Disposal Act
- Quarry Materials Act
- Mineral Resources Act
- Environmental Assessment Regulations
- (GAP) Regulations – A Certificate of Approval is required for the storage and handling of gasoline and associated products (underground or above ground)
- Provincial Accessibility Act and Regulations
- Provincial Occupational Health and Welfare Regulations
- Historic Resources Assessment Permit

Permits

- Crown Lands – Application for Grant Pursuant to Lease/Permit to Occupy Crown Land
- Application to Construct Extension or Accessory Building: alongside all Protected Roads or Development Control Areas in the Province
- Temporary Storage Remote Locations
- Sewage Treatment System Commercial – Certificate of Approval for systems
- Archaeological Research Permit – Archaeological investigations on land or under water
- Construction (Site Drainage) Certificate of Approval
- Culvert Installation, Certificate of Approval
- Well Drilling
- Water and Sewer Works for private and municipal, Certificate of Environmental Approval
- Water Course Alterations, Certificate of Environmental Approval to Alter a Body of Water
- Water Course Crossings, Certificate of Environmental Approval
- General Application for Water Use Authorization – for all beneficial uses of water from any source
- Quarry Development Permit – Exploration Permit for Geotechnical Drilling
- Provincial Land Development Approval
- Provincial approval for watercourse crossings
- Provincial approval for general construction practices
- Provincial Fuel Storage Tank Approval

- Environmental Approval for culvert installation
- Certificate of Environmental Approval for any alteration to a body of water

Municipal

- Approval to Develop Land
- Permit to Construct from local municipal jurisdiction
- Land Use Development Regulations
- Building Permits
- Protected Roads and Development Control Regulations

7 ECONOMIC AND BUSINESS CASE ANALYSIS

This section sets out the economic and business case analysis. Three cases are described:

- The Base Case - bored (TBM) tunnel with a railway shuttle;
- Upgraded Ferry Link from St Barbe to Blanc Sablon; and,
- The Base Case augmented by High Voltage Direct Current (HVDC) transmission income.

The tunnel option under consideration uses two TBM machines and a seven day work week; thus, the period for planning design and construction of the facility is 11 years and the operating period examined is 30 years, for a total economic life cycle of 41 years. Sensitivity analyses were also carried out to assess the possible effects of significant changes to the assumptions underlying these forecasts. There are three major parts to this Section, as follows:

- Transportation Demand
- Tolls and Revenue Forecasts
- Economic Evaluation

7.1 Transportation Demand

Transportation demand projections are developed based on an understanding of the existing markets served. Consideration of the potential of new market opportunities attributable to the existence of a fixed link are then developed to estimate future traffic levels. The sub-sections are as follows:

- Markets Served
- Primary Target Markets
- Traffic Projections - Fixed Link
- Traffic Projections - Upgraded Ferry Link

7.1.1 Markets Served

The existing markets for transportation between the Mainland and the Island of Newfoundland are described briefly below.

- St. Barbe to Blanc Sablon (Ferry)
- Quebec North Shore (Coastal Shipping)
- Direct Water Route (Oceanex)
- Marine Atlantic (Ferry)

St. Barbe to Blanc Sablon

Surface freight and passenger transportation between St. Barbe, NL and Blanc Sablon, QC is currently available by ferry between May 1 and mid-January, depending on weather conditions. The Government of Newfoundland and Labrador, Department of Transportation and Works recently renewed a four-year contract with Labrador Marine Inc to operate the M/V *Apollo* across the Strait of Belle Isle. The current contract started in 2004 at an annual subsidy of approximately $5.5 million including fuel that is purchased by the province on behalf of the operator. The M/V *Apollo* handles passenger and vehicle traffic only (all cargo must be in vehicles). The 108 metres long vessel has a certified passenger capacity of 240 (although it is capable of carrying 1,200 passengers), 220 cars and up to 6 tractor-trailers. The number of crossings per week varies with the season. In the peak season of July and August, the *Apollo* has 17 trips in each direction per week. For the rest of the operating period the frequency is 12 per week in May and June, 13 per week in September and October and 10 per week November 1st onwards. Each trip takes approximately 90 minutes, depending on the weather.

According to the Department of Transportation and Works, the demand for passenger service on this route has increased 59% for passengers, 76% for vehicles and 27% for tractor-trailers from 1999 to 2002. In 2003, the service was used by 23,229 vehicles (private passenger plus commercial vehicles). This service would provide a benchmark for toll pricing, revenues, traffic and costs for comparison with the impacts of a fixed link that would replace this ferry service. For year 1 (2004) of the study period a total vehicle count of 24042 was used, based on information provided by the Department of Transportation and Works.

Quebec North Shore

Access to Labrador Coastal Drive is also available by another seasonal ferry operated by Groupe Desgagnés under contract to Transports Québec. The M/V *Nordik Express* provides weekly passenger and freight service to the Quebec North Shore from Rimouski terminating at Blanc Sablon from May to January. This 1,865-ton ship has a capacity of 268 passengers with 282 m^2 of deck cargo space. The 3½-day trip stops at 10 villages between Rimouski/Sept-Îles and Blanc Sablon for passengers and freight; one trip is made each week in each direction. The volume of traffic to the Island of Newfoundland is not significant for this immediate analysis.

Oceanex

Oceanex operates a regular container service from Montréal and Halifax to St. John's and Corner Brook.

The company's fleet includes the following vessels:

- M.V. *Cabot*, a 193 metre long ice class Ro/Ro (Roll-on/Roll-off) containership constructed in 1979. The *Cabot*, which is dedicated to the Montreal service, has a capacity for 644 TEU's (Twenty-foot Equivalent Units);
- M.V. *Cicero*, a 147 metre ice class Ro/Ro containership constructed in 1978. The *Cicero*, which is dedicated to the Montreal service, has a capacity of 420 TEU's; and
- M.V. *Sanderling*, a 193 metre ice class Ro/Ro containership constructed in 1977. The *Sanderling*, which is dedicated to the Halifax service has a capacity of 1,125 TEU's.

Oceanex offers two day service between Halifax and St. John's weekly, and three day service between Montreal and St. John's twice weekly. Service to Corner Brook is provided weekly by the *Sanderling* on its return trip from St. John's to Halifax.

Prospects for diversion from this service to a new fixed link are negligible for reasons that are more fully explained later in this text.

Marine Atlantic

Marine Atlantic Inc. is a Federal Crown Corporation offering year-round passenger and freight ferry services from North Sydney, Nova Scotia to the Island of Newfoundland at Port aux Basques and summer service to Argentia. The North Sydney to Port aux Basques crossing is a constitutional obligation of Canada having been included in the Terms of Union between Canada and Newfoundland in 1949. The company's fleet includes the following vessels:

- M.V. *Caribou* -- An Ice Class 1A Super Ferry with capacity for 1200 passengers and 370 automobiles or 77 tractor-trailers. This vessel was custom built for Marine Atlantic and delivered in 1986;
- M.V. *Joseph and Clara Smallwood* -- An Ice Class 1A Super Ferry with capacity for 1200 passengers and 370 automobiles or 77 tractor-trailers. This vessel was custom built for Marine Atlantic and delivered in 1990;
- M.V. *Atlantic Freighter* -- was built in 1978 and purchased by Marine Atlantic from the Stena Line in 1986. It has capacity for 75 drop trailers and 12 passengers; and
- M.V. *Leif Ericson* -- was built in 1991 and purchased by Marine Atlantic in 2003. It has capacity for 500 passengers and 250 automobiles or 72 tractor trailers.

Off-peak season schedules to and from Newfoundland generally include twice daily ro-ro service between North Sydney and Port aux Basques using either the *Caribou* or the *Joseph and Clara Smallwood*. As well, the *Atlantic Freighter* provides drop trailer service between these ports on a demand basis.

Peak scheduling generally includes thrice daily service between North Sydney and Port aux Basques and thrice weekly service between North Sydney and Argentia. The latter is largely a passenger related service that carries very few commercial vehicles.

Crossing times, on the North Sydney to Port aux Basques service are 6 hours, and on the North Sydney to Argentia crossing, are approximately 14 hours. During peak season operations, faster sailings can occur.
The Gulf Ferries are a source of traffic that could be diverted, at least in part. Both existing and upgraded service offerings would be used as benchmark references for estimating diversion potential. Traffic originating west of Quebec City might be diverted along a new Trans Canada Highway link to Blanc Sablon along the North Shore of the Gulf of St. Lawrence.

During 2003, Gulf Services in both directions accounted for approximately 151,000 passenger vehicles and 81,000 commercial vehicles.

7.1.2 Primary Target Markets

Future potential demand for a fixed link can come from a number of sources, as follows:

- New developments to attract tourism and induced demand (i.e. new demand for trip making that is "induced" by the existence of the tunnel or the convenience it may afford, not traceable to historical trends)
- New economic developments to attract long term commercial vehicle traffic and major projects that can generate elevated demand for defined periods (e.g. construction of Lower Churchill Power Generating capacity)

Tourism And Induced Demand

Tourism is important for the economy of Newfoundland and Labrador over the time frame under consideration. New potential growth could result from creation of new National and Provincial Parks, expansion of tourism infrastructure including hotels and dining facilities, and successful major advertising campaigns. There is little specific evidence upon which to build growth projections. Implications of this type of potential are developed by indirect approaches, contacting Zonal Boards and tourism departments, and drawing inferences from comparable studies.

For example, discussions were held with representatives of Zonal Boards in Central and Southern Labrador, and Western Newfoundland to determine the status of potential major projects that could impact upon traffic demand for the Fixed Link. Based upon these discussions, no identifiable major new projects in the conceptual and initial planning stages were identified.

Provincial Trends

A number of sources have been reviewed to arrive at conclusions on the expected range of impacts from the project. Table 7.1 details the markets which the Department of Tourism, Culture and Recreation has identified as offering the best potential for tourism activity in Newfoundland and Labrador:[1]

Table 7.1 - Tourism Markets

Geographic Markets	
Primary	**Secondary**
Ontario	North-east USA
Maritimes	
Primary Purpose of Trip Markets	
Primary	**Secondary**
Sightseeing / Touring	Adventure / nature viewing
Hunting / Fishing	Meetings , Conventions and Incentive Travel

The Maritimes and Ontario are the largest non-resident markets, with the Maritime provinces accounting for 42% of non-resident visits and Ontario accounting for 32% in 2003. The primary and secondary geographic markets for Newfoundland and Labrador are similar to Nova Scotia; thus, filling "data gaps" in Newfoundland and Labrador can draw from insights obtained from studying Nova Scotia trends. See Table 7.2.

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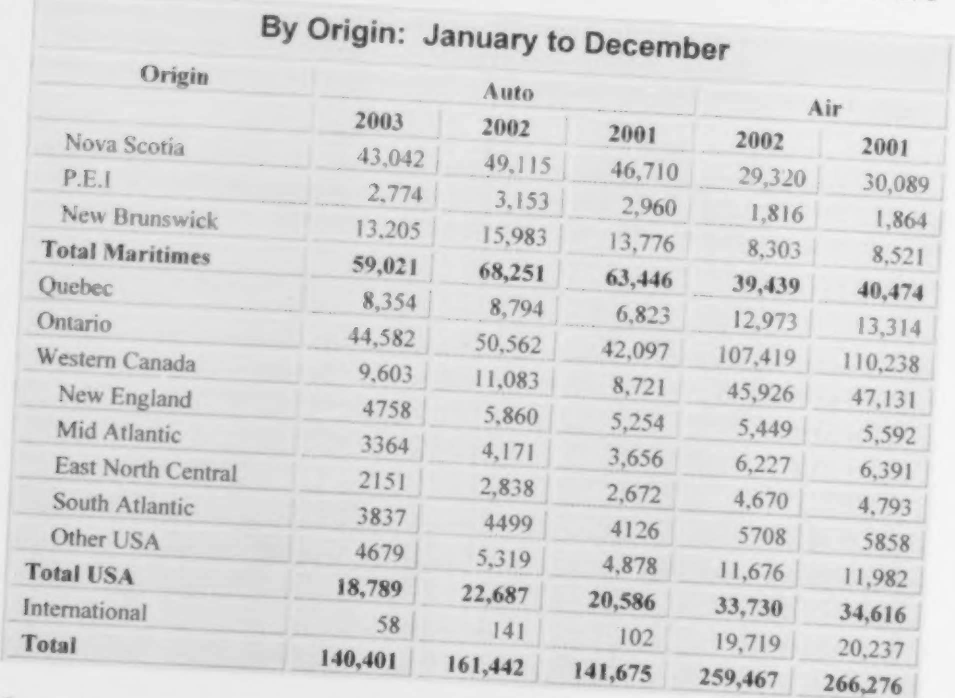
[1] *Newfoundland and Labrador Tourism Marketing Strategy Review, prepared by Economic Planning Group of Canada, November 2002, P ii.*

Table 7.2 Non-Resident Visitors to Newfoundland and Labrador



By Origin: January to December

Origin	Auto			Air	
	2003	2002	2001	2002	2001
Nova Scotia	43,042	49,115	46,710	29,320	30,089
P.E.I	2,774	3,153	2,960	1,816	1,864
New Brunswick	13,205	15,983	13,776	8,303	8,521
Total Maritimes	**59,021**	**68,251**	**63,446**	**39,439**	**40,474**
Quebec	8,354	8,794	6,823	12,973	13,314
Ontario	44,582	50,562	42,097	107,419	110,238
Western Canada	9,603	11,083	8,721	45,926	47,131
New England	4758	5,860	5,254	5,449	5,592
Mid Atlantic	3364	4,171	3,656	6,227	6,391
East North Central	2151	2,838	2,672	4,670	4,793
South Atlantic	3837	4499	4126	5708	5858
Other USA	4679	5,319	4,878	11,676	11,982
Total USA	**18,789**	**22,687**	**20,586**	**33,730**	**34,616**
International	58	141	102	19,719	20,237
Total	**140,401**	**161,442**	**141,675**	**259,467**	**266,276**

Source: Dept. of Tourism, Culture and Recreation: Data for Air travelers for 2003 were not available at the time of writing.

Table 7.3 below provides an overview of the volume of non-resident visitors to Newfoundland and Labrador for the past 10 years. Total visits to the province have increased overall by 30% from 1996 to 2003. More than half the visitors come during the peak tourist season (June-September); in fact, the ratio of peak to annual visitors has increased from around 51% in 1994 to over 54% in 2003.

Also, more recent information (Non-Resident Summary Statistics, Department of Tourism, Culture and Recreation, April 2003) reveals a newly emerging market for cruise ship arrivals. It appears to be growing from a small base of 10,000 to 20,000 visitors per year. Significant annual fluctuations since the data were first captured in 1998 conceal evidence of any trend in these early days.

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**Table 7.3 Annual Non-Resident Visits and Expenditures ($ Millions)
Newfoundland and Labrador: 1994-2003**

Year	Auto		Air		Total
	Visitors	Expenditures	Visitors	Expenditures	Visitors
1994	114,629	$46.2	214,800	$119.0	329,429
1995	118,133	$48.5	204,364	$119.9	322,497
1996	109,626	$46.3	195,436	$118.2	305,062
1997	122,425	$56.2	247,265	$175.5	369,690
1998	127,960	$60.3	244,253	$177.8	372,213
1999	140,864	$68.0	256,600	$195.4	397,464
2000	149,975	$75.3	266,480	$212.1	416,455
2001	141,675	$72.2	266,276	$215.1	407,951
2002	161,442	$85.2	259,467	$216.0	420,909
2003	140,401	$74.1(E)	287,300	$239.1(E)	427,701

Source: Department of Tourism, Culture and Recreation

(E) – estimated

The Department of Tourism, Culture and Recreation did an in-depth auto exit survey for the Province in 1997. This survey gives insight into the profile of the non-resident visitors on a sub-provincial basis. The methodology behind the survey was to administer a questionnaire to a sample of passengers in vehicles exiting Newfoundland and Labrador via Argentia or Port aux Basques on the ferry during June to October 1997.

Information from the 1997 Auto and Air Exit Survey of the Department of Tourism, Culture and Recreation is converted to 2004 dollars using the Consumer Price Index to estimate spending by tourists. The average daily expenditures for non-resident auto visitors are estimated at $93 (business), $59 (pleasure), $32 (visiting friends and relatives) and $52 (other visitors). The overall daily average is $49. Those visitors entering the Province by air have a higher overall daily expenditure at $90 with the purpose of trip breakdown being $165 (business), $128 (pleasure) and $51 (visiting friends and relatives).

From the above expenditives, distributions of traveller type have been assumed as follows:

Auto visitors:	10%	business
	30%	pleasure
	50%	visiting friends and relatives
	10%	other

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From the above expenditives, distributions of traveller type have been assumed as follows:

Auto visitors:	10%	business
	30%	pleasure
	50%	visiting friends and relatives
	10%	other

Air visitors:	20%	business
	20%	pleasure
	60%	visiting friends and relatives

These distributions provide average expenditures that approximate those given above.

For the traveller type distribution for the users of the fixed link, the business travellers have been assumed not to use the facility. Further, for the auto travellers it is assumed that the pleasure traveller component would increase signficantly. Therefore the following distributors have been used.

Auto visitors:	50%	pleasure
	40%	visiting friends and relatives
	10%	other

Air visitors:	25%	pleasure
	75%	visiting friends and relatives

Base on Table 7.3, the ratio of the auto visitors to our visitors is 35% auto versus 65% air. This gives an average expenditure to be employed in this study of $62.35 (2004 dollars).

It is apparent that air visitors are an important segment of the tourist market. Visitors from further away than the Maritime Provinces destined to tourist attractions in the Great Northern Peninsula and in Labrador tend to fly in and rent cars for their local sightseeing. Many of these tourists are round-trip travellers across the Strait of Belle Isle.

Since there is not enough information to break down the expenditures by region, this spending pattern will be taken as the benchmark for estimating incremental tourism expenditures.

Regional Tourism Insights

The 1997 Survey also estimated that on a regional basis, 37.8 % of the nights that non-residents auto visitors spent were in Western Newfoundland, 28.4% were on the Avalon Peninsula, 23.0% in Central Newfoundland, 9.7% in Eastern Newfoundland and 1.0% in Labrador.

Other findings from this survey are:

- The primary reason for travel to Newfoundland and Labrador by non-resident auto visitors was sightseeing, followed by visiting friends and family, pleasure seekers, business travelers and finally "other" reasons. ‘Pleasure’ includes outdoor recreation, special events, fishing etc.
- Greater than two-thirds of the non-resident auto visitors reported Newfoundland and Labrador as their primary destination, while less than one-third indicated the Province visit was part of an Atlantic Canada tour.
- The average party size was 2.67 persons and the most popular group composition was as husband and wife, at 41.5% of the population surveyed. The average length of stay was 11 nights with average expenditures at $41.76 per night per person (1997 dollars). Therefore, the average party was spending $1,226 per visit.
- Activities which generated the most interest in overall market segments were iceberg viewing, whale watching, boat tours, visiting historical sites/museums, scenic touring and attending festivals/events,.

These data suggest that those traveling to Newfoundland and Labrador are interested in activities related to the natural and historical heritage of the Province's coastlines.

The primary sources of data concerning Labrador include data from the annual Statistics Canada surveys of both domestic and international travel to and within Canada. The sample size for Labrador is too small for breaking out any details, but the figures do provide some sense of the number of visits. Data for the year 2000 show the following:

Overnight visits to Newfoundland & Labrador of 1 plus nights	
Overseas –	99,900
US –	49,700
Total –	149,600

Overnight visits to Labrador	
Overseas –	4,900
US –	6,700
Total –	11,600

The only other useful source of data for Labrador tourism is ad hoc data from operators throughout Labrador. There are accessible data on passenger movements across the Labrador Straits from May to October. The *Apollo* ferry data for the Labrador Straits include significant resident travel, but it may also provide a proxy for tourist visitation growth. For comparative purposes, the out-of-province visits to the Great Northern Peninsula exceed 50,000 annually.

The major attractions in the region posted visitation levels as follows:

- Red Bay National Historic Site – 8,144 between June and September 2000(6% increase over 1999).
- Pointe Amour Lighthouse – 4,584 visitors between June and October 2000 (decrease of 4% over 1999).
- Battle Harbour – average of 2,000 visitors between June and October 2000.

The Newfoundland and Labrador Exit Survey of 1997 is being updated in 2003/04. The new data are not yet available for use in this study. Therefore 1997 data is the best available indicator of current and expected future conditions. The data were compiled from interviews of air and auto visitors to the 21 tourism zones in Newfoundland and Labrador. Two zones are in Labrador and another two zones are located in the adjacent area of Western Newfoundland.

Air visitors to Southern Labrador represent less than 1.5% of the party visits, less than 0.5% of party nights and stay around five days. This profile is not expected to change significantly with a fixed link. Auto visitors have a different profile. In 1997, Southern Labrador accounted for 2.4% of party visits and 0.43% of party nights with the average stay ranging from 1.7 nights in the Labrador Straits to 3.0 nights in Mary's Harbour to Cartwright. It is important to note that the auto visitor profile for Mary's Harbour to Cartwright is representative of conditions prior to the completion of the Trans-Labrador Highway to Cartwright.

Another approach used was to examine accommodation occupancy data. The Department of Tourism, Culture and Recreation collects occupancy statistics on a monthly basis for each tourism zone. Operator participation in this survey can vary from year to year but overall trends can be isolated. As a proxy of changes in Southern Labrador and Western Newfoundland since the completion of the Trans Labrador Highway to Cartwright, the year 1999 was selected as the base year. The compounded annual increase in room nights sold was:

Zone 4	Mary's Harbour to Cartwright	2.7%
Zone 5	Labrador Straits	2.4%
Zone 4 & 5	Southern Labrador	2.5%
Zones 6 & 7	Great Northern Peninsula	3.4%

Zones 4 and 5 have spare capacity to meet increased visits from a fixed link to Newfoundland. In 2003, Southern Labrador had an annual occupancy rate of 32%. The available room nights were around 34,900 and total rooms sold were approximately 7,650. The monthly occupancy ranged from 16% in January to 64% in July and 61% in August. Occupancy rates were 47% in both shoulder months, June and September. The current accommodation occupancy profile indicates spare capacity that could be fully or partially utilized given improved access from a fixed link.

Tourism Projections

Based on the above trends and information, it is apparent that tourism to Newfoundland and Labrador is growing at an increasing rate, and that the share of market in Southern Labrador and the Great Northern Peninsula is keeping pace with the overall trend. The base case projection, therefore, with or without a fixed link will be to sustain 3.5% annual growth in tourism, broadly based on recent trends for the Great Northern Peninusula. This would be applied to a base number of visitors of 13000. This is derived from overnight visits to Labrador in year 2000 inflated by 3.5% per year to year 2004.

There is a basis to consider that the annual growth in visits can be sustained at its current level, and possibly increased with completion of a fixed link based on improved accessibility for vehicles. Emphasis on related marketing initiatives in the study area will influence the actual outcome. The excess growth over the base case projection will be used to estimate economic spin-offs attributable to construction of a link.

As mentioned above, tourist spending will be determined at the rate of $62.35 per person-night. Induced trips are based on the average overall stay of 11 nights in the province, and diverted trips are consider to add on the Great Northern Peninsula and Labrador to an existing itinerary, so one night per trip is considered to be the incremental stay. These are the factors applied to incremental trips to estimate total tourism direct expenditures as inputs to estimates of economic impact.

New Economic Developments To Attract Long Term Commercial Vehicle Traffic

Labrador is a large land mass with significant natural resources. One may envisage a long term scenario in which the development of such resources could lead to the populating of southeast parts of this land mass and to the increased movement of people, goods and services from one part of the province to the other. In such a scenario, a fixed link would promote the development of more vibrant and viable communities on both sides of the Strait. It is in the context of such a vision that a review was made in this study of potential industrial development opportunities in Labrador and how such developments might foster population growth in the area and movement across the Strait.

Mining

While there is a large mining industry in Labrador, it is located in the west and north. Discussions with the provincial government suggest that the opportunity for significant mining development in southeast Labrador is low given the geological structure of the area. This part of Labrador falls within the Grenville province which is known primarily for dimension stone rather than any commercial quantities of minerals. There may be pockets of small deposits but these would not be expected to lead to large-scale developments like Voisey's Bay, for example. If there were to be mining developments in the area, product would be very likely shipped by sea to its destination.

Forestry

A rather spasmodic, small forestry industry has existed in southern Labrador for a long time as a number of small sawmills have come and gone. Various plans have been developed for major lumber and pulp enterprises, perhaps the largest of these being the proposed harvesting of fibre for the former linerboard mill at Stephenville on the Island of Newfoundland. Today, pulpwood is cut in the Port Hope Simpson area and is barged to the Island for use by Abitibi Consolidated in Stephenville. It would not be cost competitive to ship fibre by road through a fixed link given today's fuel and paper prices, except in periods of high demand and constrained capacity by water. A small amount of lumber is also sawn as a part of this operation for use in the local area.

It might be argued that a larger sawmill industry could ship finished lumber through a fixed link to the Island for retail or for transhipment to other points. It is also possible that, if the road along the Quebec north shore were completed as part of an overall link project, lumber could be shipped westward by road.

Natural Gas

The Labrador Shelf holds substantial reserves of natural gas as proven during exploration in the area in the late 1960's. The current technology for producing, processing and shipping natural gas from offshore fields is through either a pipeline to shore or liquefying offshore and shipping in special LNG carriers. Developments are also underway to research, design and test vessels for the transport of compressed gas, without liquefaction (the so-called CNG technology), particularly from harsh environment areas such as the Grand Banks where a simplification of the processing that is done offshore would be beneficial. When, and if, Labrador gas is developed, this method may have application. It is unlikely that a pipeline to shore would be feasible because of iceberg scour, and in any event, transhipment from shore would still be required to reach market. A fixed link between Labrador and the Island of Newfoundland would have no known benefit to such an industry.

Hydroelectric Developments

The development of hydroelectric capacity on the Lower Churchill River has been referred to in this report in the context of transmitting some of the power developed to the Island of Newfoundland. The potential capacity at two sites on the river is approximately 3000 MW. It has been stated on various occasions in the public domain that these projects represent the single largest and lowest cost undeveloped hydroelectric potential in North America. One concept, which would mesh with the overall vision of integrating the two parts of the province and promoting the development of northern Newfoundland and southern Labrador, is to build an industry, based on aluminum smelting, around the availability of electricity from a Lower Churchill Development. It is well known that aluminum smelters use large amounts of electricity and the major international companies locate plants around the world at sites of low-cost power. One of the latest examples is an ongoing development in Iceland in which Alcoa is building a smelter that will use power from a new hydroelectric development in that country. There are several such existing developments in Quebec also. If one considers the concept presented in this report of a fixed link with electrical transmission cables to the Island of Newfoundland, locating a smelter at the south end of the Strait, say, in the vicinity of the fixed link terminus would be more or less synergistic with the overall objective of government of physically linking the two parts of the province, providing electrical power to the Island from the Lower Churchill, and of providing an opportunity for social and economic success in northern Newfoundland and southern Labrador. However, aluminum smelting in this area has been studied on several previous occasions and has not been pursued. There are many factors that must be considered by a large industrial customer, such as an aluminum smelter, in siting a processing facility, that are beyond the scope of this report.

7.1 Traffic Projections - Fixed Link

The primary generators of new traffic for a fixed link are tourists (entering the province by both air and road) and freight that could possibly be diverted from other routes. The tourist market has potential for significant new growth once the link is open. The freight market will likely experience modest growth and some diversion from Marine Atlantic services. The traffic growth rates assumed for the crossing, with and without a fixed link, are presented in Table 7.4.

Table 7.4 Traffic Growth Rates for Fixed Link

% Annual Growth Rates	Without Fixed Link	With Fixed Link			
		Continuing Growth	Plus Post Completion Increment		
			One-time effects		Annual Increment to Growth
			Shift	Tunnel Surge	
Strait of Belle Isle					
Tourists	3.5%	3.5%			1.25%
Local and Business	2.2%	1.5%		30.0%	
Tractor-trailers	2.5%	2.5%			
From Marine Atlantic					
Auto	2.5%		10.0%	3.0%	1.50%
Tractor-trailers	2.5%		15.0%		1.00%

Projections of traffic growth rates without a fixed link are based on a 3.5% increase in overall tourist traffic as explained earlier, with an overall growth rate for all vehicles of 2.5% per year based on long term historical trends for total traffic to the Island of Newfoundland. Using 3.5% growth for the tourist component, results in a 2.2% growth for the local and business component, to achieve an overall growth of 2.5%

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Auto	2.5%		10.0%	3.0%	1.50%
Tractor-trailers	2.5%		15.0%		1.00%

Projections of traffic growth rates without a fixed link are based on a 3.5% increase in overall tourist traffic as explained earlier, with an overall growth rate for all vehicles of 2.5% per year based on long term historical trends for total traffic to the Island of Newfoundland. Using 3.5% growth for the tourist component, results in a 2.2% growth for the local and business component, to achieve an overall growth of 2.5%

Post completion of the tunnel, four types of changes are evaluated.

- One time surge in demand affecting local and business traffic;
- Diversion from Marine Atlantic to the new fixed link;
- Sustained annual growth as indicated in the right hand column of Table 7.4
- Induced demand

The Confederation Bridge between Prince Edward Island and New Brunswick stimulated a 54% one time surge in traffic that has been sustained, but is not growing significantly from that new threshold. This suggests that travellers already operating on the route are now going back and forth with greater frequency because of the convenience of the fixed link. In the case of the proposed link across the Strait of Belle Isle, population density on either side of the link is considerably smaller than in the case of Prince Edward Island and New Brunswick and the diversity of trip purposes is relatively more restricted. Consequently, a more conservative estimate of one time surge to local and business traffic levels of 30% is used for this link. After the start of operations, the annual growth rate is used of 1.5%, slightly less than the 2.2% prior to the surge.

Determining the amount of diversion from Marine Atlantic to a fixed link is a more difficult proposition. In the first case, only that portion of traffic originating west of Québec City is likely to consider a Labrador alternative. In total, this market is about 30 to 40% of the traffic on Marine Atlantic, and a 10% overall diversion represents a significant portion of this market. With a continuous new road built along the north shore of the Gulf of St. Lawrence, some drivers might be induced to try this route, and if the experience proves rewarding then word-of-mouth advertising could sustain a reasonable growth rate.

With this optimistic outlook, the forecast traffic is based on 10% diversion of passenger vehicles from Marine Atlantic to the new fixed link. A one time induced surge in new volume equal to 30% of the diverted traffic, results in an initial traffic base for the new link that would be 13% of the previous year's projected traffic for Marine Atlantic. This traffic is assumed to continue to grow at the annual rate of 1.5%. Sensitivity analyses will test the significance of these assumptions to the overall economic assessment for the project.

With respect to freight, a net diversion from Marine Atlantic in the first year of 15% of the previous year's vehicle traffic is assumed. This is equivalent to 10% of the total trailer and container traffic to the Island, expressed as a percentage of Marine Atlantic. It is further projected that this volume will be sustained and continue to grow at a compounded annual rate of 1%.

Graphical representation of the growth in passenger and freight vehicle traffic both before and after completion of the tunnel is shown in Figures 7.1 and 7.2. The pre-operation traffic projections are self-evident, and the impact of the introduction of a fixed link is clearly shown by the sudden increase in traffic and the subsequent increased growth.

Passenger vehicle projections show the growth of the existing tourist and local markets. The largest segment, growing to approximately two thirds of the total traffic by the end of the study time frame, represents diversion and induced traffic. There is a need for more reliable information to understand this market segment and improve on these projections as the project moves forward.

A similar caveat applies to the forecasts for tractor-trailers. In this case, the reliance on traffic diversion and induced demand is even more prominent because the induced component is approximately seven times the existing traffic levels.

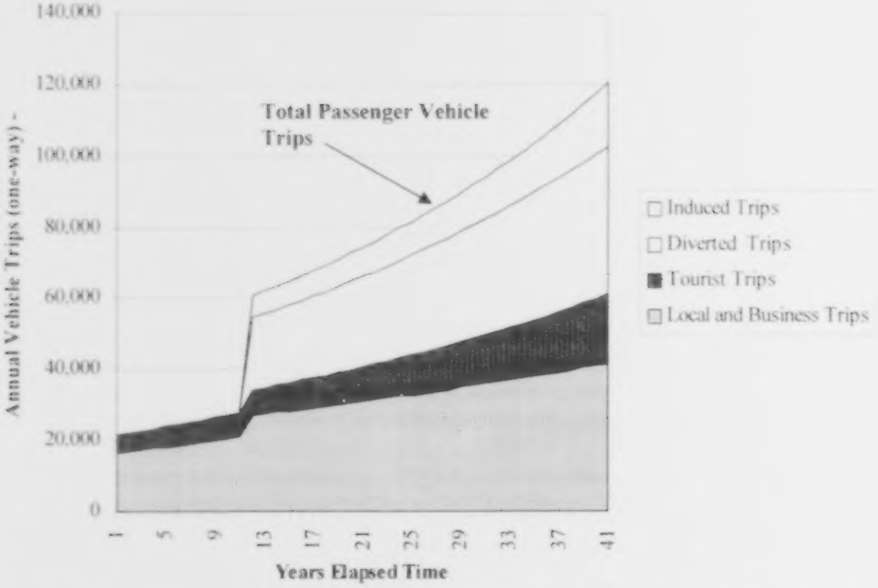

Figure 7.1 Passenger Vehicle Traffic Projections - Fixed Link

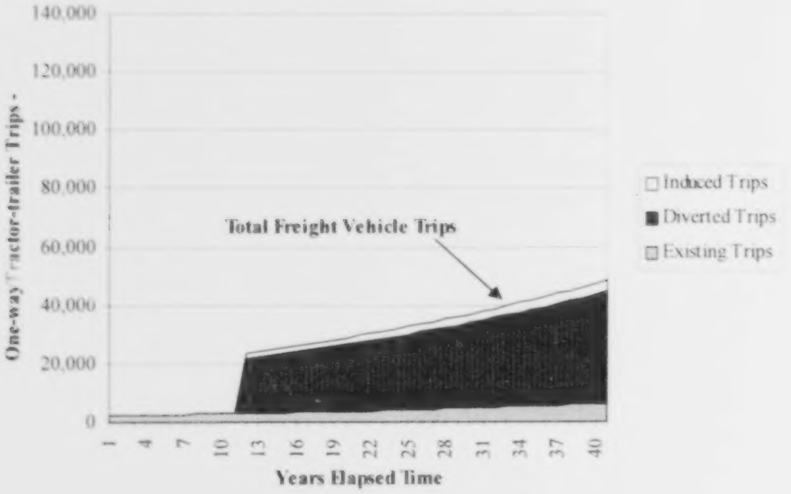

Figure 7.2 Freight Vehicle Traffic Projections - Fixed Link

Transportation carriers estimate that inbound shipments to Newfoundland exceed outbound shipments by a factor of four or five to one. The large front haul imbalance creates a very competitive environment for Newfoundland back hauls. It also assists forecasting of freight traffic since one can concentrate on the factors influencing inbound shipments. This latter statement follows from the presumption that outbound shipments can be easily handled within the surplus available capacity. If one can reasonably estimate the number of traffic units required to accommodate inbound shipments, then total movements are simply inbound traffic units times two.

During the 1980s, Transport Canada's Economic Analysis Division completed an analysis of Newfoundland's inbound freight shipments over a period of approximately 20 years. This analysis concluded that there was a correlation between Newfoundland general freight shipments and changes in provincial Real Gross Domestic Product (Real GDP). For each one percent change in Newfoundland GDP, inbound freight shipments would on average be expected to change by 0.8 to 1.0 percent.

In recent years, the Province of Newfoundland and Labrador has experienced very high real rates of growth due largely to offshore petroleum developments. Provincial economic performance for the past five years is summarized in the Table 7.5. Annual rates of growth during this period exceed national performance by approximately 90%. The largest single increase occurred in 2002. The Terra Nova offshore development commenced production then and rapidly achieved full production levels. An increase in Hibernia output also contributed to the strong growth in the same year.

Table 7.5 Newfoundland Gross Domestic Product (1997 Dollars) 1999-2003

Year	Nfld. GDP (millions)	% Change Nfld.	% Change Canada
1999	11,715	5.5	5.5
2000	12,400	5.8	5.3
2001	12,509	0.9	1.9
2002	14,432	15.4	3.3
2003	15,364	6.5	1.7
1999-2003, Average Annual Growth		6.8	3.5

While healthy growth in inbound shipments has been recorded for the period being examined, it is evident that there has been a disconnect between rates of growth in Real GDP. Inbound freight shipments (shown in Table 7.6) have grown by an average of 2.75 per cent during the 5 year period being examined which is about 40% of the increase seen in Real GDP, or one-half the historical expected rate of growth. Both major carriers have participated in the growth of the freight market from 1999 to 2003, with Oceanex increasing its share slightly.

Offshore developments and their concomitant effects on GDP, although positive, did not translate into equivalent impacts in employment and other measures of economic activity.

There is relatively little inbound freight tonnage from Goose Bay to the Island of Newfoundland or from either northern or southern Labrador communities. Freight activity to coastal communities is largely of a re-supply nature and only a limited amount of freight has been travelling on the *Apollo* service from Blanc Sablon to the Island ferry terminal in St. Barbe. As noted earlier there was a one time surge in volume during 2003, but this is excluded from the current forecasts.

While general measures of economic activity in the 1999-2003 period have indicated robust growth in the Province, there has been significant emigration and Provincial unemployment levels hover in the 15-17% range. On the Great Northern Peninsula and in Labrador, unemployment rates are as high as 24%. Clearly not all of the wealth generated in offshore petroleum fields has translated into similar increases in demand for general freight and indeed for a number of economic measures. General freight growth has of course been positively influenced by the petroleum industry and has achieved a very respectable 2.75% per annum increase despite the significant emigration and high levels of unemployment.

Table 7.6 Estimated General Freight Tonnage, Mainland to Newfoundland, 1999-2003

Marine Atlantic	1999	2000	2001	2002	2003
Tractor Trailers	337,114	338,805	342,187	356,517	351,746
Drop Trailers	322,091	325,865	338,242	329,496	353,472
Straight Trucks	9,672	9,536	10,062	9,601	9,705
Other	3,520	4,570	1,330	0	0
Total M.A. Tonnes	672,397	678,776	691,921	695,614	714,923
% of Total	59.5	59.7	59.2	58.0	57.8
Oceanex					
Containers	426,760	423,056	443,751	466,144	485,704
New Vehicles	33,656	34,365	33,849	37,378	35,833
Total Ocean. Tonnes	460,416	457,421	477,600	503,522	521,537
% of Total	40.5	40.3	40.8	42.0	42.2
Total Inbound Freight	1,129,293	1,136,197	1,169,521	1,199,136	1,236,460
Annual % Change	4.7	0.6	2.9	2.5	3.1

Transportation carriers estimate that inbound shipments to Newfoundland exceed outbound shipments by a factor of four or five to one. The large front haul imbalance creates a very competitive environment for Newfoundland back hauls. It also assists forecasting of freight traffic since one can concentrate on the factors influencing inbound shipments. This latter statement follows from the presumption that outbound shipments can be easily handled within the surplus available capacity. If one can reasonably estimate the number of traffic units required to accommodate inbound shipments, then total movements are simply inbound traffic units times two.

During the 1980s, Transport Canada's Economic Analysis Division completed an analysis of Newfoundland's inbound freight shipments over a period of approximately 20 years. This analysis concluded that there was a correlation between Newfoundland general freight shipments and changes in provincial Real Gross Domestic Product (Real GDP). For each one percent change in Newfoundland GDP, inbound freight shipments would on average be expected to change by 0.8 to 1.0 percent.

In recent years, the Province of Newfoundland and Labrador has experienced very high real rates of growth due largely to offshore petroleum developments. Provincial economic performance for the past five years is summarized in the Table 7.5. Annual rates of growth during this period exceed national performance by approximately 90%. The largest single increase occurred in 2002. The Terra Nova offshore development commenced production then and rapidly achieved full production levels. An increase in Hibernia output also contributed to the strong growth in the same year.

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Annual % Change	4.7	0.6	2.9	2.5	3.1

There are some indications that emigration is levelling off and that the Newfoundland and Labrador economy will continue to record positive rates of growth in the 2.5% range for both 2004 and 2005. For years beyond 2005, the Newfoundland and Labrador Department of Finance notes that GDP will increase at higher rates owing to oil from the White Rose offshore project and the start of Voisey's Bay nickel production. The Department of Finance has adjusted future GDP projections to "exclude production income from major projects accruing to non-residents." These adjusted numbers show very little growth in the 2006-2007 period. It is interesting to note that the adjusted Real GDP figure for 2003 shows a 2.0% increase versus an unadjusted growth of 4.7%.

Based on recent history and the projection of modest growth for the short to medium term, a 2.5% per annum growth for general freight shipments for the duration of the study period is considered to be realistic as a base case.

Traffic diversion and induced demand represented the dominant source of traffic, as noted earlier. The reasons for great caution and uncertainty concerning this diversion potential are explained below.

The discussion, which follows is intended to reflect a carrier's perspective and largely pertains to driver accompanied traffic. Furthermore, the modal choice variables discussed are not mutually exclusive.

Distance Travelled

For shipments from central Canada to the Island of Newfoundland one can compute the impact of a fixed link by choosing common link points. Two common link points for a central Canadian shipment to Newfoundland using a fixed link or the existing Gulf Ferry service are Quebec City and St. John's as shown on Figure 7.3. Presupposing a highway is constructed along the north shore of the St. Lawrence to connect the Labrador Straits area with Natashquan and points west, driving distances from Quebec City to St. John's are roughly equal. There will therefore, be no distance advantage for highway-based travel from Central Canada to the Island of Newfoundland using a fixed link.

For travel from the Maritimes using Halifax as the point of departure, the fixed link route would add approximately 1,450 kilometres to a St. John's destination compared to the existing highway/Gulf Ferry connection. Therefore, for all practical purposes the fixed link routing alternative is not a viable alternative for Maritime province based travel.

Travel Time

Travel time is a function of distance and operating speed. From the above, using the Quebec City and St. John's link points, distances for both alternatives are equal. Operating speeds on the highways however could be expected to be different. Operating speeds on the Trans-Canada Highway from Quebec City to St. John's will be in the 100-110 kilometre per hour range. Virtually all of the Quebec to North Sydney portion of the highway is, or soon will be, four lane controlled access highway with posted speeds ranging from 100 to 110 kilometres per hour. Travellers along the North Shore of the St. Lawrence can be expected to experience operating speeds of 80 to 90 kilometres per hour. Similar average operating speeds on the Great Northern Peninsula section of highway can be expected. The Gulf Ferry takes approximately 6 hours with all vehicular traffic requested to be at the terminal at least one hour in advance of sailing (i.e. total of 7 hours). The fixed link crossing would take about 25 to 60 minutes, inclusive of terminal time. Thus a travel time advantage will occur in respect of the crossing.

Combining the impacts of operating speeds and crossing times, however, there is minimal difference in overall travel time from central Canada to the Island of Newfoundland. Figure 7.3 shows road distances between Quebec City and St. John's with driving times calculated based on the above speed assumptions. Ferry crossing times are not included in the times shown.

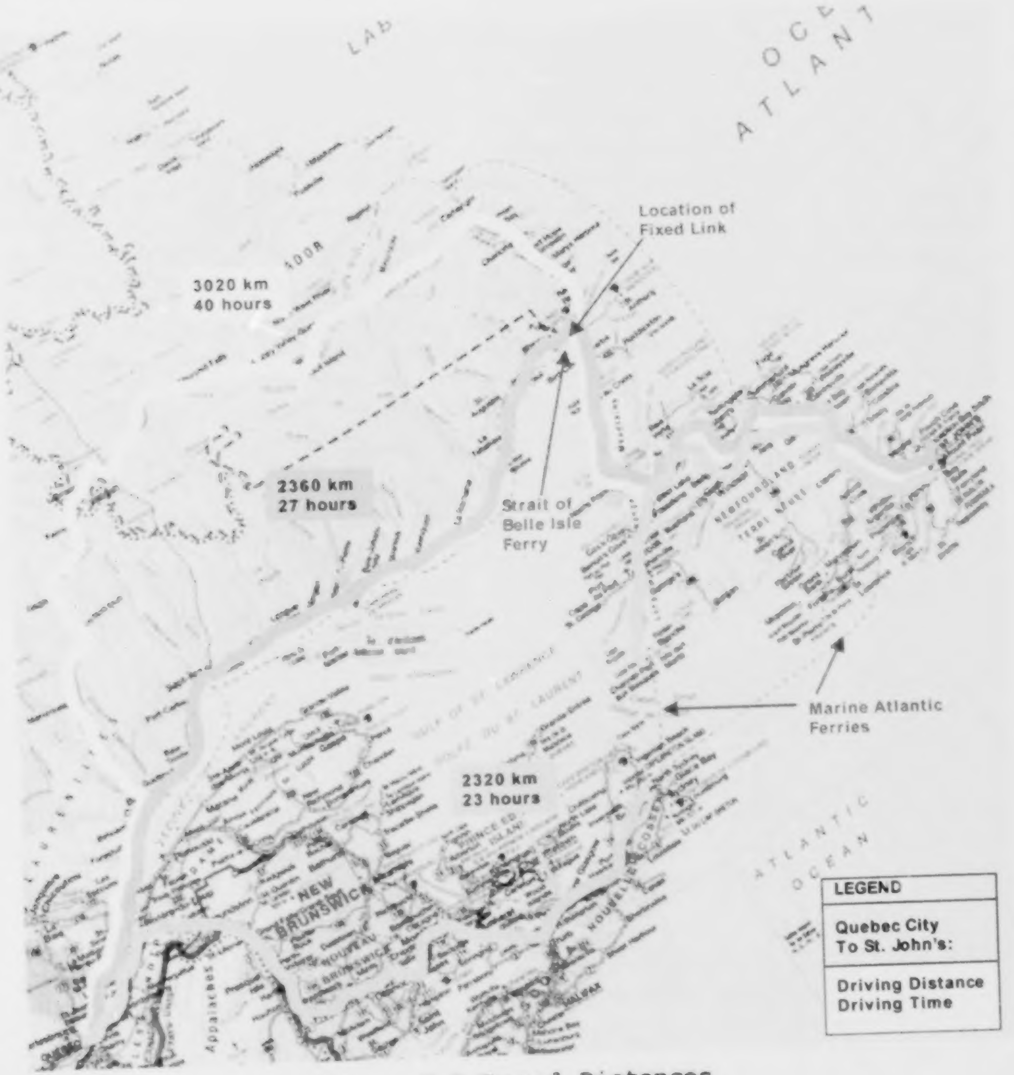
LABRADOR
OCEAN ATLANTIC
Location of Fixed Link
3020 km
40 hours
2360 km
27 hours
Strait of Belle Isle Ferry
NEWFOUNDLAND
Marine Atlantic Ferries
GULF OF ST. LAWRENCE
GOLFE DU ST. LAURENT
2320 km
23 hours
PRINCE EDWARD ISLAND
NEW BRUNSWICK
NOUVEAU BRUNSWICK
NOVA SCOTIA
ATLANTIC OCEAN
Appalaches
LEGEND
Quebec City To St. John's:
Driving Distance
Driving Time

Figure 7.3 Travel Distances

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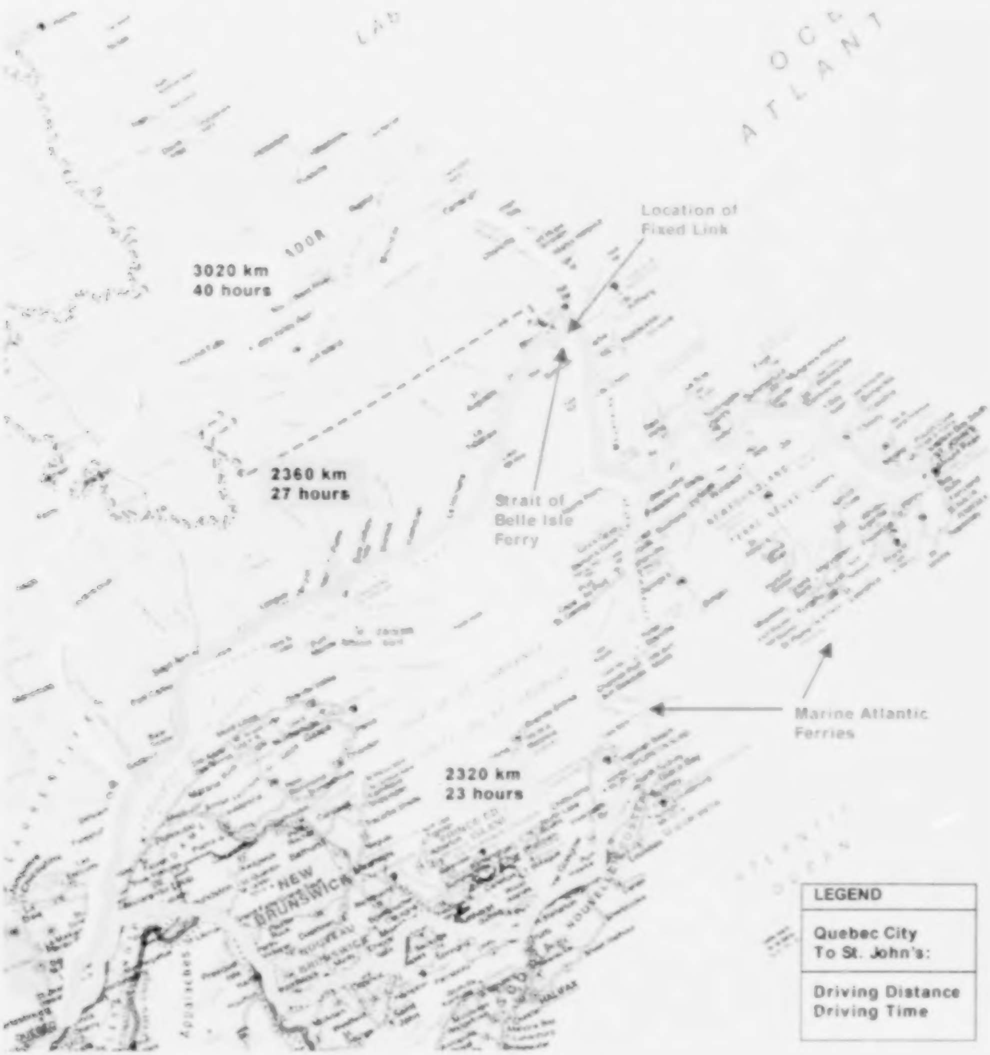
Location of Fixed Link
3020 km
40 hours
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23 hours
NEW BRUNSWICK
NOUVEAU-BRUNSWICK
Appalaches
LEGEND
Quebec City To St. John's:
Driving Distance
Driving Time

Figure 7.3 Travel Distances

Reliability

Service interruption due to unfavourable ambient conditions (high winds, ice conditions) or vessel repairs is a frequently mentioned concern associated with the Gulf Ferry service. The proposed fixed link will be immune to ambient conditions in the Strait of Belle Isle and from this perspective will provide heightened reliability compared to the Gulf Ferry service.

Winter weather conditions along the north shore of the St. Lawrence and the Great Northern Peninsula are probably worse than those along the Trans-Canada Highway for travel from Quebec to Nova Scotia although detailed inspection of meteorological data and the impact on highway conditions was not carried out for this study. With respect to mechanical interruptions, a fixed link rail tunnel is likely to have a reliability advantage over the ferry.

In total, therefore, a fixed link and connecting roadway accesses would be expected to provide an enhanced level of reliability compared to the existing highway and ferry alternative.

Terrain

Roadway gradients and curvature are significant contributors to operating costs for motorized freight traffic. Steep coastal fjords are present along the North Shore of the St. Lawrence and through parts of the Great Northern Peninsula and, potentially, create a large number of steep inclines/declines. While these conditions are present along the Trans-Canada Highway from Quebec to Deer Lake (notably in the Riviere du Loup to Edmundston and Cape Breton sections) their length is relatively short and mitigation has occurred as a consequence of geometric improvements to the highway. An operating advantage to the existing Gulf Ferry route would occur as a consequence.

Weight Limitations

Restrictions on the Gross Vehicle Weights (GVWs) of trucks are imposed on Canadian highways to reflect vulnerability of underlying roadbeds and/or surface material to heavy loads. These restrictions are frequently implemented during spring operating conditions but can be imposed year round if highway quality dictates. Trans Canada Highway weight limits are generally unrestricted year round. Since the alternative route via the north shore of the St. Lawrence is yet to be constructed, it would be reasonable to expect that weight limits would also be unrestricted on this route.

Claims

Damage to vehicles or cargo is a function of operating conditions and the quality and frequency of handling. Operating conditions along the existing route are considered to be more favourable than on a future route along the north shore of the St. Lawrence and on the Great Northern Peninsula. While this would lend some support to the existing route, one must also consider the impact of vessel loading and marine operating conditions on the Gulf Ferry service. Operating conditions dictate that freight traffic is tied to the vessel deck to prevent damaging movements of vehicles. Drop trailer traffic is also tied down but is loaded and unloaded with yard tractors. Marine Atlantic staff is believed to have a good claims record for these procedures but damage does occur. It is felt that the fixed link route will have a marginal net advantage in claims experience.

Competition

One of the factors affecting utilization of new routing alternatives is the presence and viability of competing means of access. The existing Gulf Ferry service is a constitutional commitment of Canada to the Province of Newfoundland, which is enshrined in the 1949 Terms of Union. Furthermore it serves an important trade corridor that will not disappear with the construction of a fixed link.

There will always be a need for a robust, and likely subsidized, ferry service. The degree of subsidization may be an issue if a fixed link is built. The Gulf Ferry, during 2003, achieved an operating cost recovery of 57.6%. On a total operating budget of $111.1 million, a federal subsidy of $43.8 million was required. Pressure to reduce the operating subsidy, and even make a contribution to capital requirements, would likely ensue if a fixed link were constructed.

Increases in rates and reduction of operating costs through efficiencies and/or service level reductions would be targeted but their overall occurrence and degree of such moves would be a matter of government policy. Given that the current rate for moving a 60-foot tractor-trailer and driver across the Gulf Ferry Service is $284.25 while the comparable rate for the *Apollo* Service is $161.25 (the assumed rate structure for the fixed link) some price elasticity of demand impacts on the Gulf Ferry service would be expected and are accounted for in the traffic diversion estimates.

Oceanex, in providing service from Montreal and Halifax to St. John's and Corner Brook, is an important player in Newfoundland freight transportation, having some 42% of the market place in 2003. The company has increased the overall volume of traffic moved and its market share during the past five years. In December of 2003, Oceanex announced that it would be purchasing a new 150-metre ice-class container ship to be delivered in 2005. The new vessel will increase weekly capacity from Montreal by some 350 TEU's per week and provide operating efficiencies in the form of fuel savings and a fully automated engine room. The new ship will be designed to handle 53-foot containers and have movable container cell guides to provide maximum operating flexibility for future changes in customer requirements. Oceanex may also increase the frequency of Halifax sailings if they decide to retain the M.V. *Cicero* and thus expand the fleet size from three to four vessels.

The overall likely outcome of the Oceanex capacity addition is that the company will strengthen its competitive position with respect to all existing and contemplated freight options to Newfoundland. The freight traffic forecasts for a fixed link, therefore, contain no diversion of traffic from Oceanex.

Table 7.7 summarizes the discussion on modal share variables that will affect freight shipments to Newfoundland in a fixed link environment.

Table 7.7 Modal Share Variables and Impacts

Variable	Fixed Link vs Gulf Ferry Alternative	Conclusion
Driving Distance	Equal distance for Central Canadian traffic but significant advantage to Gulf Ferry for service via Maritimes	Gulf Ferry position is strong for Maritime traffic and neutral for Central Canadian traffic
Travel Time	Operating speeds in favour of Gulf Ferry route and crossing time differentials in favour of fixed link essentially balance out	Neutral
Reliability	Crossing reliability higher for a fixed link but winter highway conditions may be more favourable for Gulf Ferry route	Increased reliability for fixed link
Terrain	More difficult terrain on fixed link route will increase operating costs versus Gulf Ferry Route	Gulf Ferry route is superior
Weight Limitations	Weight restrictions along the Northshore St. Lawrence highway will likely be upgraded to TCH standards	Neutral
Claim	Claims from poor operating conditions along North Shore St. Lawrence highway more than compensated by handling claimed on Gulf Ferry service	Slightly better claims experience with fixed link
Competition	Gulf Ferry service and direct water services will remain with good quality / frequency of service to compete with fixed link	Gulf ferry is more vulnerable than direct water service but will still be a very significant component of future freight service.

7.1.4 Traffic Projections – Upgraded Ferry

For the upgraded ferry it is important to analyse the practicality of increasing the service. During July and August, the MV *Apollo* presently provides up to three return voyages per day. For a 90 minute crossing and 60 minute turnaround at the terminal, this presents a 13.5 hour operating day. By increasing the operating day to 18 hours, four return voyages are possible. This is considered to be the maximum number of trips for a single ship ferry. An upgraded ferry service would therefore, extend this maximum service level for a longer season and provide service for the rest of the year. The proposed service frequency is presented in Table 7.8, with the existing frequency for comparison.

Table 7.8 Ferry Service Frequency for Strait of Belle Isle

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Trips/Month													
Present	9*	0	0	0	52	52	74	74	56	56	43	19*	435
Upgraded	93	84	93	120	124	120	124	124	120	120	90	93	1305
Trips/Day													
Present	1-2	0	0	0	1-2	1-2	2-3	2-3	1-2	1-2	1-2	1-2	
Upgraded	3	3	3	4	4	4	4	4	4	4	3	3	

*varies with weather conditions

For the single ship, this level of service would result in scheduled sailings, at 5 hour intervals. Therefore, a traveller would experience a minimum of 2.5 hours travel time for the crossing and a maximum of 7 hours, the latter if the traveller misses or fails to get on a particular sailing.

Projections were developed for a case representing substantial upgrade to the existing ferry services across the Straits of Belle Isle. Cost projections are developed to be representative of extending the operating season for as long as possible (essentially year-round operations for purposes of economic comparison). Ship replacement continuing with a status quo arrangement has been estimated to cost approximately $75 million (2004 dollars). The costs of an upgraded vessel are not precisely known because the vessel design would depend on service plans. For purposes of this analysis, a conservative estimate with a 100% premium is used. Therefore, approximately $150 million (2004 dollars) is considered to be the upgraded vessel cost representing a larger Ice Class 1A Ferry or two vessels of equivalent total capacity to offer higher peak frequency, using the same replacement timing as the base case.

The annual subsidy is presumed to double on account of a longer sailing season and increased frequency of sailing. This would represent approximately three times as many departures as at present, mostly occurring in the extended season, although there would be also peak season enhancement. The rationale for this estimate is as follows:

- Subsidy for operating the existing service is $5.5 million per year (2004 dollars), and the revenues would be approximately $2 million by year 11, for a total annual operating cost of $7.5 million;
- It is estimated that 50% of these total costs are variable with the number of voyages, that is $3.5 million (rough rule-of-thumb for fuel, crew and terminal wages, supplies and repairs);
- Tripling the number of departures would triple these costs to $10.5 million per year, bringing the total operating cost to $14.5 million per year (2004 dollars);
- With revenues in the range of $3.5 million in year 12, the gap that would be met by subsidies would be about $11 million, or approximately double the present subsidy.

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[illegible] Traffic Projections - Upgraded [illegible]

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Present	1-2	0	0	0	1-2	1-2	2-3	2-3	1-2	1-2	1-2	1-2	
Upgraded	3	3	3	4	4	4	4	4	4	4	3	3	

*varies with weather conditions

For the single ship, this level of service would result in scheduled sailings, at 5 hour intervals. Therefore, a traveller would experience a minimum of 2.5 hours travel time for the crossing and a maximum of 7 hours, the latter if the traveller misses or fails to get on a particular sailing.

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The annual subsidy is presumed to double on account of a longer sailing season and increased frequency of sailing. This would represent approximately three times as many departures as at present, mostly occurring in the extended season, although there would be also peak season enhancement. The rationale for this estimate is as follows:

- Subsidy for operating the existing service is $5.5 million per year (2004 dollars), and the revenues would be approximately $2 million by year 11, for a total annual operating cost of $7.5 million;
- It is estimated that 50% of these total costs are variable with the number of voyages, that is $3.5 million (rough rule-of-thumb for fuel, crew and terminal wages, supplies and repairs);
- Tripling the number of departures would triple these costs to $10.5 million per year, bringing the total operating cost to $14.5 million per year (2004 dollars);
- With revenues in the range of $3.5 million in year 12, the gap that would be met by subsidies would be about $11 million, or approximately double the present subsidy.

The timing for introduction of service improvements would coincide with completion of the Highway 138 extension to Blanc Sablon, presumably in the same general time frame as is considered for the fixed link construction.

The growth assumptions applicable to the existing traffic base employed for this case are as follows:

- Tourist trips would continue to grow at an annual rate of 3.5% throughout the study time frame;
- Local and residential travel will experience a 15% one-time surge upon introduction of the new service, followed by growth at the rate of 1.5% annually.
- Tourist travel will experience increased annual growth of 0.5% following completion of the highway and introduction of the new service;
- Truck traffic would experience 2% (of total Oceanex and Marine Atlantic, equivalent to 3% of Marine Atlantic) diversion from the Cabot Strait and would continue to grow annually at previously established growth rates.
- Auto traffic would experience a 1% diversion from the Cabot Strait

These assumptions are presented in Table 7.9

Table 7.9 Traffic Growth Rates for Upgraded Ferry

% Annual Growth Rates	Existing Ferry	With Upgraded Ferry			
		Continuing Growth	Plus Post Completion Increment		
			One-time effects		Annual Increment to Growth
			Shift	Tunnel Surge	
Strait of Belle Isle					
Tourists	3.5%	3.5%			0.5%
Local and Business	2.2%	1.5%		15.0%	0%
Tractor-trailers	2.5%	2.5%			0%
From Marine Atlantic					
Auto	2.5%		1%	0%	0%
Tractor-trailers	2.5%		3%		0%

This set of assumptions is considered as reliable and appropriate as any other in the absence of detailed market data to test sensitivity to these improvements. The growth rates are reduced from those for the fixed link based on the less attractive level of service and potential delays associated with the upgraded ferry. The results, in terms of annual vehicle trips for passenger cars and trucks, are shown in Figures 7.4 and 7.5.

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- Tourist travel will experience increased annual growth of 0.5% following completion of the highway and introduction of the new service;
- Truck traffic would experience 2% (of total Oceanex and Marine Atlantic, equivalent to 3% of Marine Atlantic) diversion from the Cabot Strait and would continue to grow annually at previously established growth rates.
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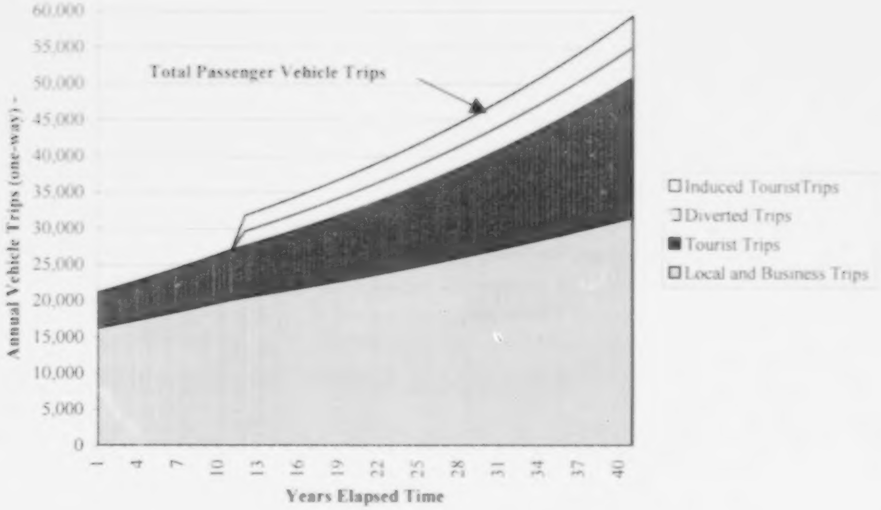

Figure 7.4 Passenger Vehicle Traffic Projections - Upgraded Ferry

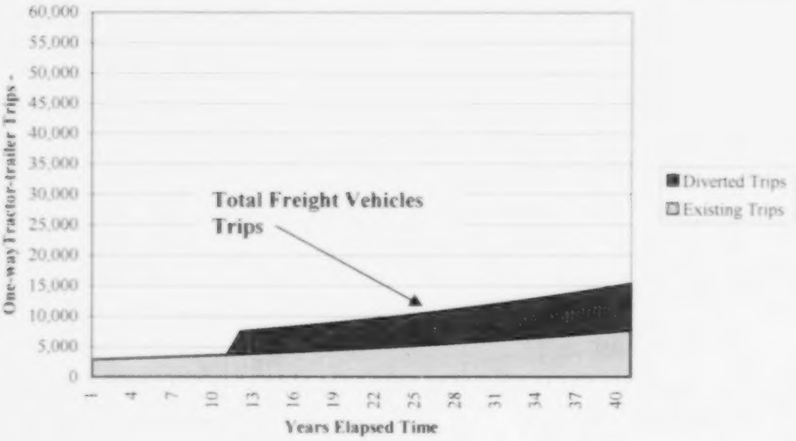

Figure 7.5 Freight Vehicle Traffic Projections - Upgraded Ferry

7.2 Tolls and Revenue Forecasts

Revenue forecast were devleoped for the three cases noted previously. Revenues were caiculated based on existing *Apollo* tolls these are $30.50 per vehicle and driver and $10 per additional passenger. Freight revenues were based on the existing average revenue per tractor-trailer on the *Apollo*,of $161.25. The resulting revenue projections for the base case for the study operating period of 30 years are shown on Figure 7.6.

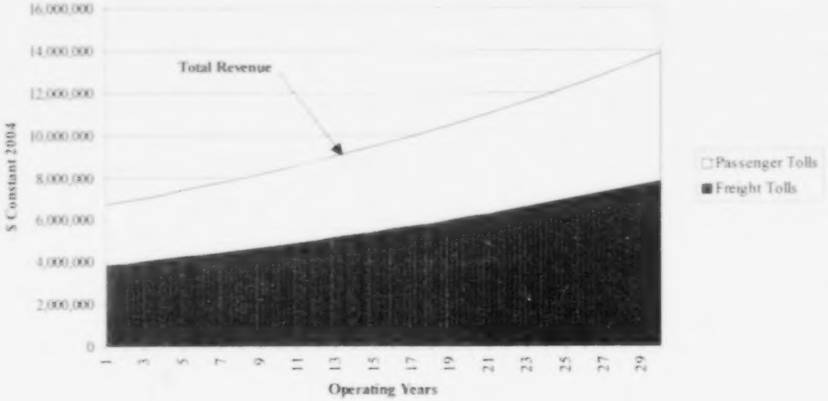

Figure 7.6 Fixed Link Revenue Projections

Similarly, Figure 7.7 shows revenue projections for the case of an upgraded ferry for the same operating period.

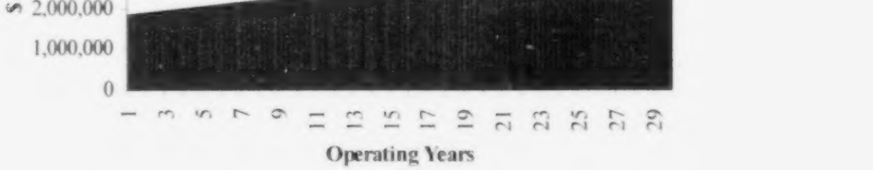

Figure 7.7 Upgraded Ferry Revenue Projections

The third case examined is the Base Case with revenue from HVDC transmission cables within a fixed link. Project cost estimates were developed to include HVDC power cables in the fixed link on behalf of Newfoundland and Labrador Hydro (NLH), as part of a future transmission line between Labrador and the Island. For purposes of the economic analysis, NLH also provided capital cost estimates to install submarine cables across the Strait. These costs would be avoided if the transmission line were to go ahead using the fixed link across the Strait. The incremental capital and operations cost attributable to the HVDC line in the fixed link are virtually insignificant compared to the other costs except for the power cables and their installation. The issue is how to value this opportunity for a power transmission facility. The approach applied to forecasting a reasonable revenue stream was based on the amortization of the avoided capital cost of an HVDC installation in the fixed link versus a dedicated submarine HVDC system over the 30-year time horizon of this study. The range of potential revenue streams considered is as follows:

- Cable cost recovery - that which results in neither incremental cost nor revenue to the tunnel owner – below that, losses would be incurred and be of no interest to the tunnel owner; this would be represented by amortization of the cable installation and annual cable maintenance costs;
- Highest possible revenue - the annualized equivalent of 100% of the costs that would be avoided by NLH by using this facility instead of building a dedicated crossing – higher charges would drive the power utility to a dedicated facility, if the market could support it;
- An intermediate value - revenue that might ultimately be negotiated between the tunnel developers and the utility.

In the absence of a final determination of developing the hydro potential of Labrador and the consequential decision to deliver hydro electricity to the Island of Newfoundland, the outcome of such negotiations is premature to predict at present. Consequently, for purposes of evaluating the revenue impact of hydro transmission, it was considered most reasonable to use a median between the limits and to calculation a case at 50% of the avoided cost of a dedicated hydro link. The upper and lower limits would be checked in sensitivity analyses. In all three cases, the annual fees are based on amortization to null residual value over a period of 30 operating years.

Table 7.10 Annual HVDC Revenue Ranges

$ Millions (constant 2004)	Lowest Limit	Highest Limit	Mid Point
Recovery of Cable Costs	$7.1	$7.1	$7.1
Transmission Revenue	-	$34.4	$17.2
Total	$7.1	$41.5	$24.3

Consequently, the transportation toll revenue would be augmented by a real constant annual amount equivalent to one of the totals shown in Table 7.10, depending upon the case under consideration. For purposes of the analysis, for the Base Case with HVDC income case, $24.3M per year was used.

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7.3 Economic Evaluation

Three indicators of economic value are employed for the base case and various sensitivity tests that were conducted. The three indicators are Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit Cost Ratio (BCR). Descriptions of the application of each of these are as follows:

- NPV is calculated using a real social discount rate of 7.5%, which is the recommended rate of the Federal Treasury Board assuming annual inflation at 2.5% over the project time horizon(i.e. 10% nominal). The net cash flow for each year (positive or negative) is discounted to reflect the equivalent value in 2004, and all the years are summed to one total NPV.
- IRR is calculated internally, before cash flows are discounted; it is the effective discount rate that would produce a null NPV.
- BCR is calculated using the same cash flow inputs as the NPV, except activities that are meant to produce benefits are separated from those that are meant to cause cost and are summed independently of each other. The ratio of the summed benefits to the summed costs is the BCR; values greater than one are desirable and suggest economic justification; values less than one are undesirable but not necessarily conclusive in themselves, without taking into account external factors that are not quantified in the analysis.

Each of the three indicators was estimated in accordance with three distinct perspectives for each case studied. The perspectives depend upon the nature of the observer (private investor, lending institution, government, etc.) and they reflect increasing scope from a strictly internal cash-flow perspective to a broader socio-economic context. The three levels are:

- **Internal revenues and costs** for planning, design, construction and operation of the tunnel – this would be the most appropriate perspective for a proponent considering stand-alone development and exploitation of the project;
- **Economic impacts** directly attributable to the fixed link, such as changes to the revenues and costs of existing marine ferries in the Cabot and Belle Isle Straits, and it would include some external effects such as environmental mitigation, safety enhancement, reduced delays and congestion etc. (which are estimated to be insignificant in this case) – this would be an appropriate perspective for a transportation economist to use to estimate net effects on the industry or on subsidies;
- **Socio-economic impacts** include consequential stimulation of GDP growth in the province from the activity of construction and subsequent tourism and other activities, and other externalites that might include quality of life improvements that could be estimated – these estimates are macro-economic in nature and tend to be used as public policy indicators; they are difficult to measure in small scale systems because data are rarely available; in this study, aggregate indicators used by the Newfoundland Department of Finance were provided to the team.

7.3.1 Internal Revenues and Costs

The profile of cash outflows over 30 years of operations for the base case after construction is completed is illustrated in Figure 7.8. In constant currency terms, the costs are uniform for a fixed level of operation except for periodic major maintenance consisting of major equipment replacement shown as peaks in years 7, 12, 16, 20, 25 and 30.

During the study, it was determined that the shuttle operation could be commissioned incrementally to match the development of traffic. This refinement has not been incorporated into the analysis. The full fleet is assumed in the first year of operation.

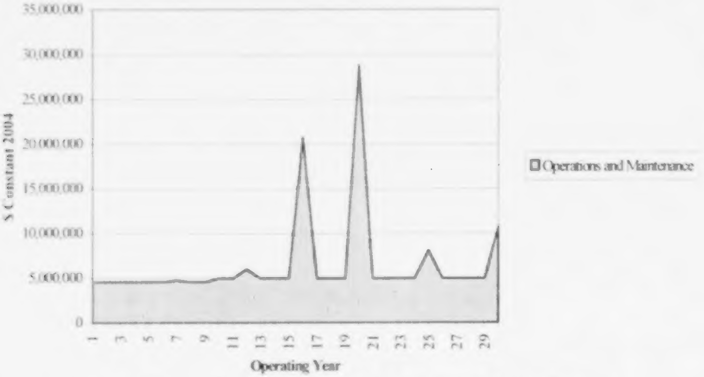

Figure 7.8 Costs by Operating Year

Figure 7.9 shows the effect of combining the revenue and costs from Figures 7.6 and 7.8 and converting the resulting cash flow to present value for the Base Case.

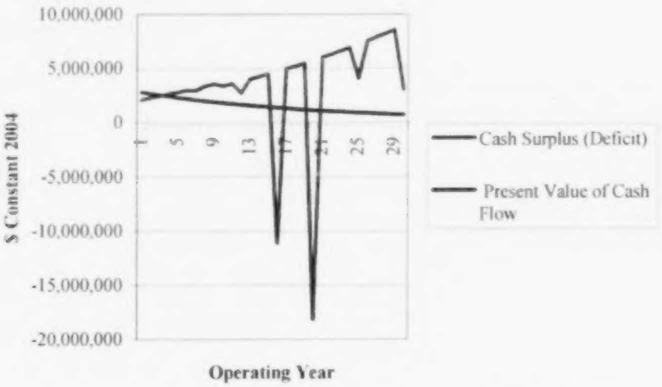

Figure 7.9 Operating Cash Flow in 2004 dollars

The upper red line in figure 7.9 represents the net result of subtracting the operating costs from the base case revenues and the lower black line represents those same values discounted to present value at 2004, considering also that year 1 in the graph is actually year 12 in the project life cycle. The effect of long time frames in a project of this nature are clearly evident in the gap between the two lines in Figure 7.9.

7.3.2 Present Value Analysis for Base Case

For the Base Case, project economics are presented for the entire project life cycle assuming an 11 year period of planning, design and construction and 30 year period of operation. Figure 7.10 presents the annual present values in 2004 dollars for the internal economics of the project. Figure 7.11 modifies these annual values by including the economic effects of avoidance of the present Strait of Belle Isle ferry operating deficit costs and minor adjustments that would result to the Gulf Ferry costs. Figure 7.12 further modifies the annual values by including the social benefits in terms of increased economic activity that may be caused by the project.

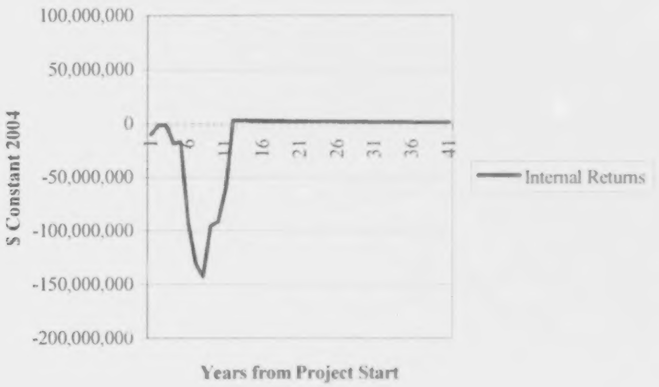

Figure 7.10 Annual Net Present Values (Internal Returns) Base Case

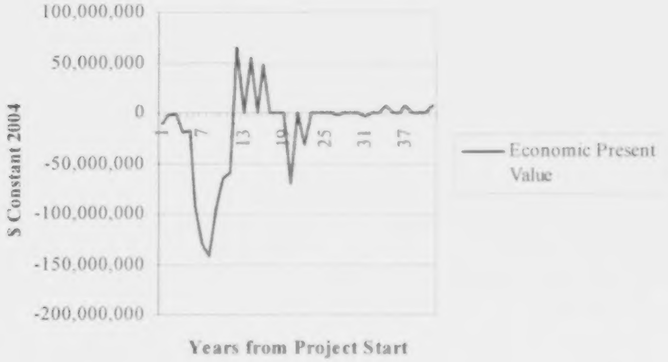

Figure 7.11 Annual Net Present Values (with Economic Returns) Base Case

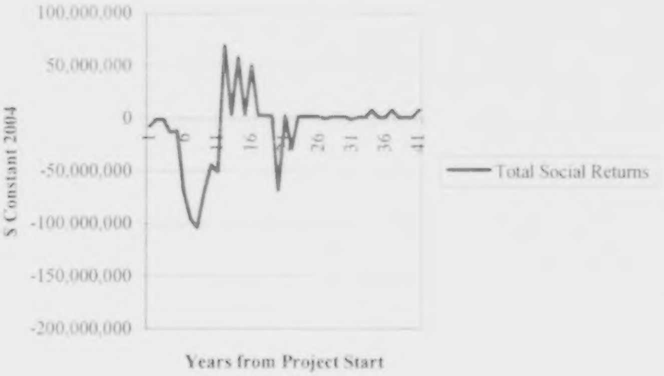

Figure 7.12 Annual Net Present Values (with Social Returns) Base Case

The capital development costs are shown, in Figures 7.10, 7.11 and 7.12, as negative amounts occurring in years 1 through 11. Since these occur early in the time frame, they are not so heavily discounted as the revenue stream, which does not start until much later. The economic present value graph, Figure 7.11, also includes the impacts on Marine Atlantic and the avoided costs of replacing the *Apollo*. Deferral and avoidance of ship replacements account for all of the positive peaks appearing post year 12. The ship replacement assumptions are the critical drivers of the external economic benefits. These assumptions would have to be reviewed, particularly with Marine Atlantic, in light of the actual projected timing of events if there is a decision to proceed further.

The projected economic impacts of tourism development, GDP stimulation and employment during construction are combined with the other benefits and shown in Figure 7.12. While these are significant in themselves, when discounted over a long period of time and compared with the scale of the costs of the project, they show up as minor. One exception occurs in the early years in which the GDP impacts of indirect and induced economic activity during construction offsets in part the impact of the costs.

The direct, indirect and induced impacts on GDP, wages and employment were determined using information provided by the Newfoundland and Labrador Department of Finance. The approach used is to split the impacts into direct, indirect and induced. Direct investment, labour income and employment information was provided by the project team. The indirect impacts (which are impacts generated when companies supply inputs to the direct activity) use indirect multipliers for standard industries generated from Economic Input/Output data. The induced impacts (which are impacts generated when direct and indirect employees and business owners spend their earnings in the general economy) are estimated using a multiplier of 0.3, but for employment this may need to be adjusted up or down depending on the average wage rates in direct and indirect industries. For example, the 0.3 induced impact is the average for the entire economy, but if the average wage in the direct and indirect industries is twice the average wage in the entire economy then more money will most likely be spent per direct and indirect employee and the induced impacts are larger. In this case we would use an induced employment multiplier of 0.6. If the direct and indirect wage rates were half the economy average one would use an induced multiplier of 0.15.

Specifically, in this project, and based on communications with the Department of Finance, the following parameters were selected:

For Construction:

Since the Transportation Engineering Construction industry is the industry which most closely resembles tunnel construction its parameters were used. For estimating direct effects, data for 2000 puts the GDP to gross output ratio at 34%, the labour income to gross output ratio at 22% and the employment per $1 million of expenditure/gross output at 6 full time equivalent jobs. To estimate the indirect impacts the following multipliers were averaged over the 1997 to 2000 period:

- GDP 0.63
- Labour income 0.53
- Employment 0.63.

The induced multiplier of 0.3 is applied to the direct and indirect impacts. (This is based on average annual labour income per person year (full year equivalent) of employment in 2003 at $35,200, calculated by dividing Labour Force Survey employment into total labour income from Statistics Canada Provincial Economic Accounts).

For Tunnel Operation:

Since the Rail Transportation is the industry that most closely resembles tunnel operation its parameters were used. To estimate the indirect impacts the following multipliers were used for rail transportation; they are averaged over the 1997 to 2000 period.

- GDP 0.28
- Labour income 0.85
- Employment 0.71.
- Induced multiplier 0.3.

For Tourism:

While data are available for auto and air tourism impacts, the travel information concerning the target market is sparse, and the time frame is relatively far out in the future so that composite industry assumptions are used. Based on 1998 spending Department of Finance came up with the following estimates of the direct impacts from non-resident tourist spending (excluding spending on marine transportation).

- Direct GDP 0.35
- Direct labour income 0.24
- Direct employment per $1 million, 12.8 full time equivalent jobs

The indirect multipliers are:

- GDP 0.44
- Labour income 0.33
- Employment 0.24.
- Induced multiplier 0.15.

7.3.3 Present Value Analysis for the Upgraded Ferry

For the upgraded ferry, the project economics are presented for the entire life cycle of the project assuming the implementation of the new service at year 12. Figure 7.13 present the annnual net present values in 2004 dollars for the internal economics of the project. The negitive peak at year 10 indicates the vessel acquistion the peak at year 40 shows the vessel replacement. Figure 7.14 modifies these annual net present values by including the economic effects of avoidance of the present ferry operating deficit costs. Figure 7.15 further modifies the annual net present values by including the social benefits in terms of increased economic activity that may be caused by the project. It should be noted that the social benefits associated with this case are relatively small.

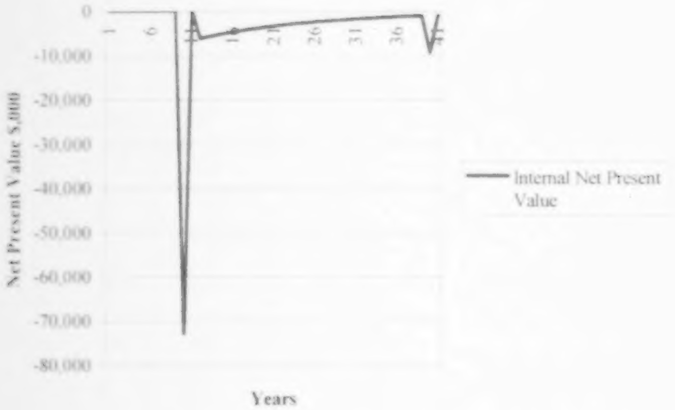

Figure 7.13 Annual Net Present Values (Internal Returns) Upgraded Ferry

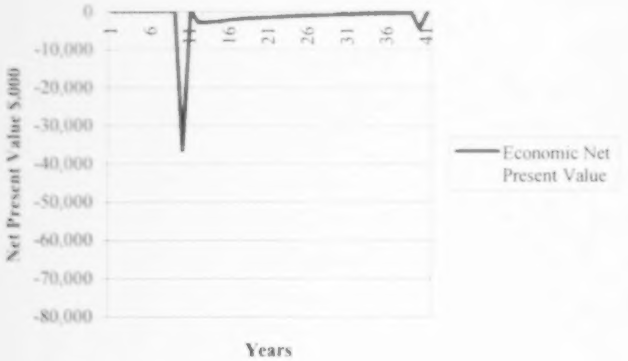

Figure 7.14 Annual Net Present Values (with Economic Returns) Upgrade Ferry

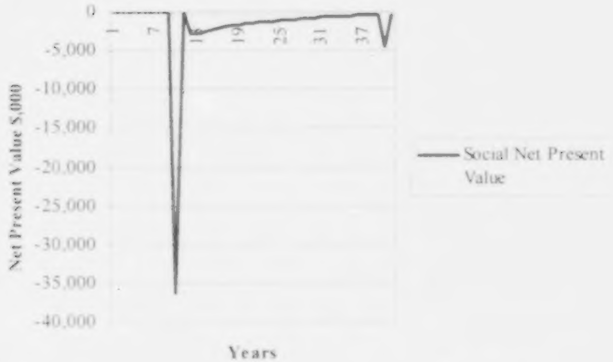

Figure 7.15 Annual Net Present Values (with Social Returns) Upgraded Ferry

7.3.4 Results of Economic Analyses

The results of applying the method outlined above to each case are shown in Table 7.11. The Internal Returns section of the table refers to the recovery of the fixed link or upgraded ferry investment and recovery of the capital investment (i.e. costs) from the operating benefits – cash flow from operations.

The Base Case and the HVDC Case have both positive and negative cash flow so all three measures are applied for comparison purposes (NPV, IRR and BCR). The Ferry Upgrade does not have any years with positive cash flow therefore IRR cannot be calculated. Results are shown in Table 7.11.

Table 7.11 Economic Evaluation Results

LEVEL	CASE	NPV	IRR	BCR
		$ millions 2004	%	#
Internal Returns	BASE CASE	- $648	-9.5%	0.07
	HVDC	-$554	-2.1%	0.25
	FERRY UPGRADE	-$164	N/A	0.13
Internal Returns & Economic Returns	BASE CASE	-$559	-5.2%	0.20
	HVDC	-$466	-1.0%	0.37
	FERRY UPGRADE	-$116	N/A	0.38
Internal Returns & Economic Returns & Social Returns	BASE CASE	-$333	-1.3%	0.53
	HVDC	-$240	1.6%	0.68
	FERRY UPGRADE	-$114	N/A	0.39

The following observations apply to Table 7.11:

- The NPVs are all negative - this clearly places every alternative in the realm of the public sector because quantifiable benefits are insufficient to sustain viability.
- Including HVDC in the fixed link improves all indicators and improves the NPV by $94 million (at 50% sharing of avoidable cost). At 100% of the avoidable cost, the NPV would improve by a further $84 million.
- Upgrading the Strait of Belle Isle ferry service is significantly less costly compared to the base case – the NPV for Economic Returns is negative $116 million. The negative $116 million NPV results from increases to annual subsidies for the ferry, plus Marine Atlantic loss increases resulting from revenue diversion, plus ship replacement.
- The Benefit Cost Ratios (BCR) are all substantially less than unity – suggesting that project justification, if pursued would have to depend on factors that are external to this study, e.g. consequences of electrical energy transmission, social and political considerations associated with uniting the Province with a physical link.
- The difference between internal cash flows and economic impacts generates an improvement in NPV around $89 million
- The Social Returns for the Base Case, which include GDP growth effects of incremental tourism and activity stimulated by construction of the fixed link generate additional impacts around $226 million NPV ($2004 dollars).

Figures 7.16, 7.17 & 7.18 show the data presented in Table 7.11 in graphical form for ease of comparison.

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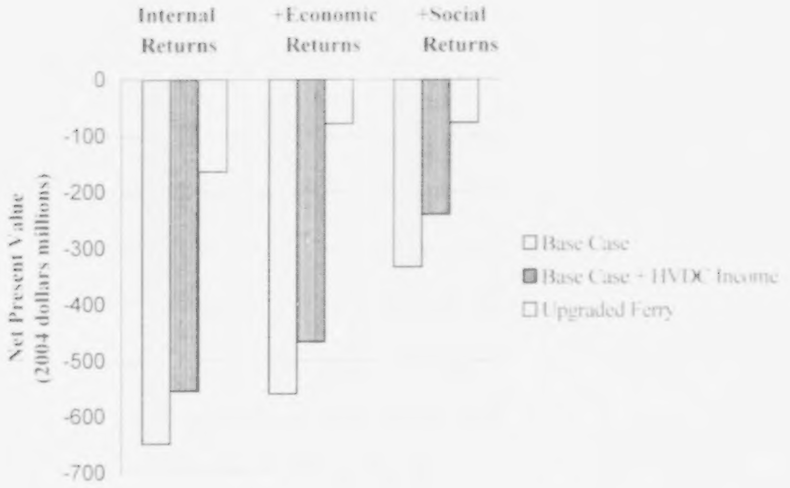


Figure 7.16 Net Present Values for Each Study Case

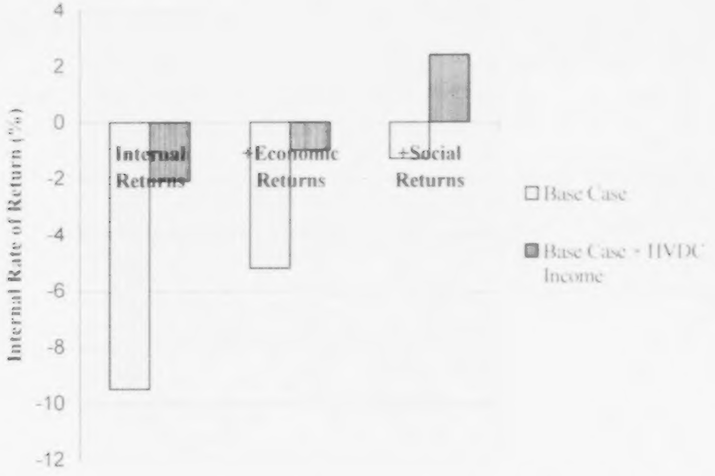
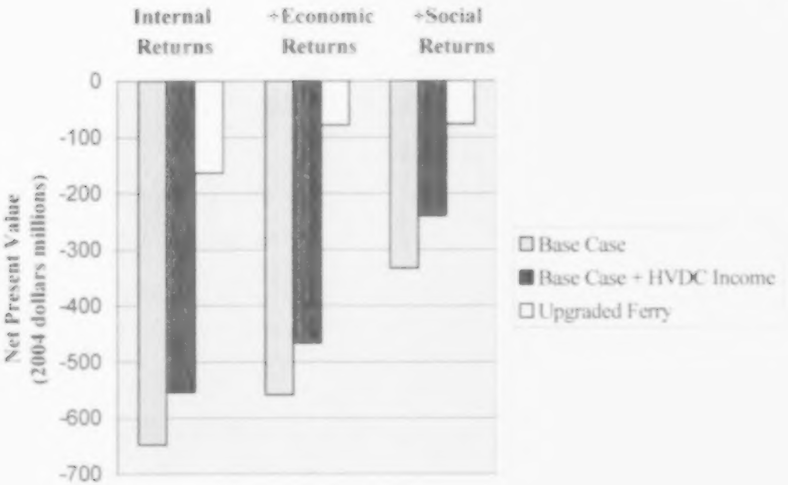


Figure 7.17 Internal Rates of Return for Each Study Case (where calculable)



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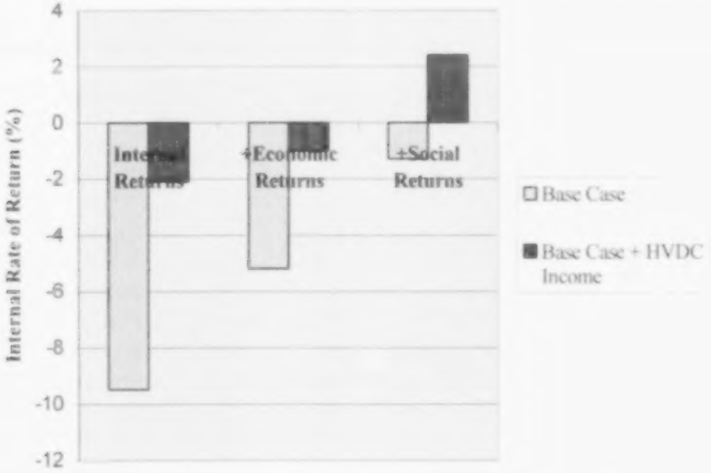

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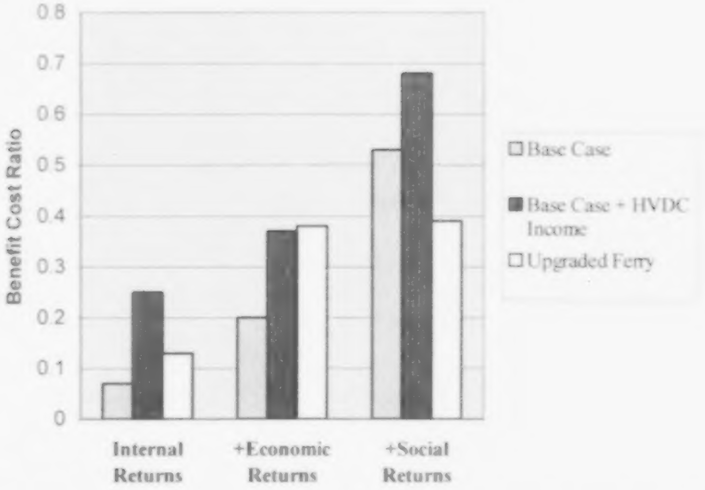

Figure 7.18 Benefit/Cost Returns for Each Study Case

In addition to the analyses described above, various sensitivity tests were carried out to determine if these findings are sufficiently robust and to support overall project conclusions. The sensitivity to electricity transmission tolls is significant, as mentioned above. Tolls for freight and passenger vehicles were also tested.

Table 7.12 below shows the results for a range of variation in toll revenues for the base case demand levels. For example, doubling the tolls with inelastic demand could have the effect of improving NPV by $46 million and increasing the Internal BCR from 0.07 to 0.14. The absence of reliable market information at this time precludes delving further into this topic. Demand factors and elasticity to tolls should be examined much more closely, particularly in the years approaching tunnel completion.

Table 7.12 Economic Sensitivity Analysis to Toll Revenue

			Unit Toll % of Base Case Value		
Results		**Base Case**	**50%**	**150%**	**200%**
Internal Project Revenues and Costs	NPV $millions	-$648	-$671	-$625	-$602
	IRR	-9.53%	N/A	-6.60%	-4.84%
	BCR	0.07	0.03	0.10	0.13
Economic Impacts	NPV $millions	-$559	-$582	-$536	-$513
	IRR%	-5.28%	-6.66%	-4.11%	-3.09%
	BCR	0.19	0.16	0.23	0.26
Socio-Economic Impacts	NPV $millions	-$333	-$356	-$310	-$288
	IRR	-1.4%	-2.5%	-0.4%	-0.4%
	BCR	0.52	0.49	0.55	0.59

Variations in traffic growth rates for different segments(e.g. local and business travelers, diverted tourists and induced travel) were evaluated. No major impacts were observed. In general, the range of change in NPV attributable to market variations is less than 10% of the base case over the maximum extent of the range, as reflected in Table 7.13.

Table 7.13 Traffic and Cost Sensitivity Analyses

Description	Range Tested	NPV Range $MM	NPV Range/Base Case
Toll Rates	50–200% of Base Case	69	11%
Diversion ex Cabot	0-15%	44	7%
Incremental Growth Rate	2.5-7.5%	20	3%
Operating Costs	50-200% of Base Case	46	7%
Capital Costs	70-130% of Base Case	398	61%

Operating and capital costs were also considered. Capital costs were tested over the design range of accuracy of the estimates for this pre-feasibility study (i.e. plus/minus 30%), as also shown in Table 7.13. Clearly, the results are very sensitive to capital costs and accuracy of cost estimates represents a significant risk factor going forward.

With respect to the upgraded ferry option, the significant factor is vessel replacement cost. If the actual vessel cost were $100 million, instead of $150 million, then the overall impact on NPV would be $27 million (2004 dollars). That is the NPV for Economic Impacts would be negative $52 million instead of negative $79 million.

Operating cost projection uncertainty is not very significant relative to capital cost. Over a range of half to double the base case value, the total impact is only 7% of the base case NPV. These costs are planning details that would have to be considered more thoroughly in a full feasibility study and operating plan, however they do not affect the general thrust of the findings in this report.

Table 7.14 Discount and Inflation Rate Sensitivity Analysis

		Nominal Social Discount Rate					**Inflation Rate**			
Results		**4.0%**	**6.0%**	**8.0%**	**10.0%**	**12.0%**	**1.0%**	**2.0%**	**4.0%**	**5.5%**
Operating Cash Flow	NPV $MM	-$985	-$858	-$746	-$648	-$564	-$584	-$626	-$720	-$800
	IRR %	-9.53%	-9.53%	-9.53%	-9.53%	-9.53%	-.9.53%	-9.53%	-9.53%	-9.53%
	BCR	0.17	0.12	0.09	0.07	0.05	0.05	0.06	0.08	0.10
Direct Economic Impact	NPC $MM	-$829	-$737	-$644	-$559	-$486	-$503	-$540	-$621	-$690
	IRR %	-5.28%	-5.28%	-5.28%	-5.28%	-5.28%	-5.28%	-5.28%	-5.28%	-5.28%
	BCR	0.30	0.24	0.21	0.19	0.18	0.18	0.19	0.21	0.23
With Indirect and Induced Impacts	NPV $MM	-$325	-$367	-$359	-$333	-$302	-$310	-$326	-$354	-$367
	IRR %	-1.42%	-1.42%	-1.42%	-1.42%	-142%	-1.42%	-1.42%	-1.42%	-1.42%
	BCR	0.72	0.62	0.56	0.52	0.49	0.50	0.51	0.55	0.59

Sensitivity to the social discount rate and to projected inflation is significant also. Table 7.14 illustrates results for comparison to the base case (Nominal discount rate – 10%, Inflation rate 2.5%). Higher discount rates improve the NPV and diminish the BCR because the front end costs are so high compared to the downstream benefits. A range of plus/minus 2% around the base case causes the NPV range to extend over 15% of the base case amount. This is a significant variation.

The inflation rate also is significant, and along with capital costs, represent the most significant risk factors in economic terms. The difference between 1% and 4% inflation is $217 million in terms of net present value or 33% of the base case NPV.

Finally, significant spikes in the costs and benefits are noted when the vessels in existing ferry services to the Island of Newfoundland need to be replaced, or additions to the fleet are required. The timing of these events have a more significant impact than variations to internal revenues or costs after the tunnel is operating. Further, these events can happen throughout the entire project lifecycle, especially in years prior to start up of revenues. A full feasibility study of the tunnel would require coordinated planning approach involving Marine Atlantic (with respect to funding decisions) and the existing ferry services to Labrador (with respect to both subsidies and funding ship replacement).

If Highway 138 were not completed, then it would be reasonable to compare the base case to a case with neither diversion nor incremental/induced growth, but with traditional growth levels sustained. In such a case the NPV would be reduced another $170 million. The consequential mitigation of negative value would be modest. In other words, without completion of Highway 138 to the tunnel entrance, in the same time frame as the tunnel is built, the Net Present Value of the tunnel project would be $170 million lower than with the highway. This is a major risk factor that would be removed with a commitment to complete Highway 138.

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	BCR	0.17	0.12	0.09	0.07	0.05	0.05	0.06	0.08	0.10
Direct Economic Impact	NPC $MM	-$829	-$737	-$644	-$559	-$486	-$503	-$540	-$621	-$690
	IRR %	-5.28%	-5.28%	-5.28%	-5.28%	-5.28%	-5.28%	-5.28%	-5.28%	-5.28%
	BCR	0.30	0.24	0.21	0.19	0.18	0.18	0.19	0.21	0.23
With Indirect and Induced Impacts	NPV $MM	-$325	-$367	-$359	-$333	-$302	-$310	-$326	-$354	-$367
	IRR %	-1.42%	-1.42%	-1.42%	-1.42%	-142%	-1.42%	-1.42%	-1.42%	-1.42%
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Finally, significant spikes in the costs and benefits are noted when the vessels in existing ferry services to the Island of Newfoundland need to be replaced, or additions to the fleet are required. The timing of these events have a more significant impact than variations to internal revenues or costs after the tunnel is operating. Further, these events can happen throughout the entire project lifecycle, especially in years prior to start up of revenues. A full feasibility study of the tunnel would require coordinated planning approach involving Marine Atlantic (with respect to funding decisions) and the existing ferry services to Labrador (with respect to both subsidies and funding ship replacement).

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In summary, the major risk factors emerging from the sensitivity analysis are uncertainty in development and construction costs (not an unusual occurrence at this stage of considering a major infrastructure undertaking), uncertainty regarding completion of Highway 138 on the St. Lawrence Lower North Shore, and, to a lesser extent, inflation.

Employment impacts were also determined for each case described above. There is not much variation between the cases, and the overall impacts are summarized as follows:

- Employment during construction is around 350-500 Full Time Equivalent (FTE) jobs for 6 years
- 40 new permanent jobs for operations & maintenance, replacing the part-time ferry

Total employment impact including spin-off effects

- 1,000 FTE (approx.) during construction (6 years)
- 350 FTE initially on start-up, growing to 550 FTE over 30 years
- Net Present Value of all wages $400 million

A further sensitivity analysis was carried out for the ferry upgrade option in which the upgraded ferry is introduced at year 5, instead of year 11 to match the fixed link, as assumed in the previous analysis. This has the effect of increasing the size of the economic negative net present value from negative $79M to negative $84M as the costs are incurred earlier. This option does, however, provide the improved service at an earlier date than for the fixed link.

8 FINANCING CONSIDERATIONS & FINANCIAL ANALYSIS

8.1 Financing Considerations

Governments have traditionally invested directly in roads and transit systems, and operated them as part of government. However, since the early 1990's, many governments have adopted models where the private sector funds, designs, builds, and operates roadways and transit systems. This practice is widespread in England, Australia, New Zealand, and Asia, and is becoming more common in North America. The Government of Canada has also demonstrated a growing interest in shared financing over the last decade.

Public Infrastructure Financing Alternatives

Public Private Partnerships (PPP's) permit Governments to finance development of public infrastructure and provision of public services through access to private capital markets. With the application of PPP's increasing over the last decade, they are now widely acknowledged by both the private and public sectors as a way of drawing on the expertise of both groups to provide a long-term mutual benefit.

Governments have implemented PPP's throughout the world under a variety of different models with a variety of different names. A recurring theme in these initiatives is to avoid having to increase the level of public sector debt.

The rationale for a public-private partnership usually results from:

- a shortage of government funds
- a desire to obtain the benefits of private sector project management;
- transfer of risks to private companies; and
- greater flexibility in management and efficiency in operations enjoyed by the private sector.
- Increase level of 'user pays' in the community

International experience has proven that the involvement of the private sector in the delivery of public infrastructure can deliver value for money through the transfer of risk, particularly the risk associated with ridership levels, innovation, and project delivery responsibility.
Other benefits of the PPP include:

- Commercialisation of revenues: the private sector often focuses on developing commercial opportunities associated with the project.
- Access to capital: Government funds are usually limited. PPP's provide an alternative funding source.
- Accountability and on-time delivery: PPP's allow the Government to penalize the private sector when they do not meet the contracted timeline or budget.
- Cost of funds: the cost of the private sector funds reflect the full risk associated with the project.

There are many models which may be adopted for the implementation of a PPP. At one end, the private sector may provide all or most of the funding, and absorb major risks associated with the project – construction costs, delays, lower than projected revenue, higher than expected operating costs. At the other, the private sector's role may be limited to designing and building a facility within broadly specified parameters and operating for a fixed income. In the middle, a private contractor may take the risks of design, construction, and schedule, but be guaranteed revenues sufficient to cover the bid cost of the project and subsequent operations.

In determining the appropriate scope and structure of the PPP for the particular project Government's must consider:

- What is the preferred delivery option, i.e. the bundling of different elements of project delivery into a single contract.
- What physical and functional components of the project are to be under private sector ownership and control, i.e. stations; infrastructure; rolling stock; and
- What network components are included in the PPP, i.e. the airport and commuter elements of the project and the existing system.

Table 8.1 summarizes a number of examples of transportation infrastructure finance through public private partnerships.

Table 8.1 - Example Transportation Infrastructure PPP Projects

Project	Comments
Confederation Bridge (Prince Edward Island/ New Brunswick) (1987)	• New 12.9 km fixed link bridge over Northumberland Straight between PEI and New Brunswick - $1 billion in direct construction costs • In response to three unsolicited bids for bridge-tunnel solution in 1985- 1986, Federal Government issued a Request for Expressions of Interest in 1987 seeking innovative designs that would provide long-term fixed link • 35-year agreement for the design, build, financing and maintenance of the Confederation Bridge awarded in 1993. At end of contract, bridge transferred to Government for $1. Construction completed in 1997 • Government pays annual lease payment of $41.9M (1992 dollars) escalated at 75% of CPI – equal to previous ferry subsidy. Operators able to collect tolls. Lease payments securitised for $660 million and toll revenues for $328 million
Charleswood Bridge (Manitoba) 1994	• New 152 metre bridge over Winnipeg's Assiniboine River (and associated roadworks) – $15M in capital costs • Bridge awarded on a design, build, finance, own, maintain, transfer basis – City of Winnipeg to make annual ascending lease payments under a 30-year lease
Highway 104 (Nova Scotia) (1997)	• Province needed to build a safe 45-km by-pass on the TransCanada Highway (the Cobequid Pass) faster than would be possible with public sector delivery. • Design, build operate (toll system) awarded – project built for $113M • Off-balance-sheet financing of not-for-profit entity responsible for collecting tolls, operations and maintenance. Federal/Provincial Governments each contributed $27.5M and $5.5M of subordinated debt was provided by the Sydney Steel Corporation pension fund
Highway 407 (Ontario) (1993 and 1999)	• In 1993 the Province issued an RFP seeking mechanisms to build the 69- km highway more quickly, cheaply and with lower risk to the taxpayer. • Highway 407 Central was to be designed, built, financed by toll revenues, operated and maintained by the successful bidder over a 35 year concession period. Province later modified the franchise to a design, build, operate and transfer scheme with the financing responsibility retained by the government. This meant that the financing, traffic and revenue risks remained with the government. • In 1999, the Province sold a 99-year concession for Highway 407 central, together with the right/obligation to make 39-km of extensions for $3.1B.
The Channel Tunnel (France and England) (1987)	• The Channel Tunnel is a unique case and in many respects not typical of private project finance. The operator was at arm's length from the construction companies which wanted to build the tunnel and the banks who wanted to finance it. • Due to the complexity of the project, Eurotunnel let a design and build contract to the original construction companies operating as a joint venture. • The original estimated total cost was of the order of €7.5 billion in 1987 prices, with almost half of this sum to be provided by equity capital and the rest by loans. The total cost increased progressively during construction to over €16 billion. • Most of the additional cost was covered by additional loans, although some dilution of the equity has taken place through rights issues and some debt for equity swaps as the company struggled to meet its debt charges. The governments agreed to successive increases in the length of the concession, from an initial 55 years to an eventual 99 years.
Other examples of infrastructures financed through PPP / and Potential new projects	• New Brunswick toll highway • French, Spanish, Australian toll-ways • RailTrack in UK • Winnipeg Red River diversion canal • Lower Mainland port/rail infrastructure improvements / expansion. Gateway Transportation strategy and RAV line (potential projects) • Detroit - Windsor tunnel • Peace Bridge expansion (Fort Erie-Buffalo)

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PRIVATE FINANCE AND RISK CONSIDERATIONS

Privately financed infrastructure faces three main types of risk: construction risk, revenue and maintenance risk and planning and political risk. Construction risks arise because of the individuality of large infrastructure projects and their long gestation periods, both of which make costs difficult to estimate accurately.

Once infrastructure is completed, infrastructure providers also face operational risks. Where usage is below that expected there may be revenue risks. Finally, and most difficult to assess, are the policy and planning risks which any infrastructure provider has to take into account. The long gestation periods and the longevity of payback periods for major projects makes them vulnerable to changes of policy. Table 8.2 summarizes risk types and risk allocation.

As a consequence of the inherited risks of building and managing new infrastructure, private finance usually demands an equity return calculated by determining an appropriate risk premium above a forecast risk-free rate. Risk premiums are generally set by regulator entities. In Canada this risk premium has historically ranged between 3% and 5%.

Table 8.2 - Risk Type and Possible Risk Allocation [2]

	Public Sector	Builder	Operator	Private Lender	Private Owner
Approval Process	X				
Development		X			X
Design		X		O	
Construction		X		O	X
Operation			X	O	X
Maintenance			X		X
Demand			X	O	X
Revenue			O	O	X
Interest Rate				O	X
Exchange Rate				O	X
Inflation				O	X
Taxation					X
Environmental	X	O			O
Regulatory / Political	X			O	X
Injury / Damage	O	X	X		X
Residual Value				O	X
Obsolescence			O		X
Legacy Defects	X	O	O	O	O
(i.e. Polluted Site)	X: Principal risk taker		O: Secondary risk taker		

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[2] *British Columbia Investing Management Corporation, Infrastructure Investing, Nov 2003.*

Private Finance and Risk Transference

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Taxation					X
Environmental	X	O			O
Regulatory / Political	X			O	X
Injury / Damage	O	X	X		X
Residual Value				O	X
Obsolescence			O		X
Legacy Defects	X	O	O	O	O
(i.e. Polluted Site)	X: Principal risk taker		O: Secondary risk taker		

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All of these factors are present in the present situation.

Capital Markets – Expectations

Canadian investment managers expect equity markets to stay the course in 2004 and expect equities to outperform bonds according to Mercer Investment Consulting 2004 Canadian Fearless Forecast.

For 2004, the investment managers forecast equity returns to be in the range of 8% to 12%, with Canadian small capital and emerging markets cited as the most favourable markets. For bond and cash markets, the managers expect more modest returns ranging from 2.8% to 4.5%. For the Canadian equity market, the managers predict the material, energy, and financial sectors to be the top performers.

Looking further down the road, the Canadian investment managers forecast 5-year median equity returns to be in the range of 8% per annum to 10% per annum, while bond and cash markets are forecast to be in a more modest range of 3.4% per annum to 5.5% per annum.

Government of Canada Bonds offer attractive returns and are fully guaranteed by the federal government. They are available for terms of one to 30 years and like T-Bills, are essentially risk-free if held to maturity. Currently 5 to 10 year Government of Canada Marketable Bonds average yield is around 4.80%, the yield for more than 10 years bonds is around 5.41%[3]. Standard and Poor's, Moody's and DBRS rate AAA Stable Canada's long-Term Domestic and Foreign Debt[4].

Canada's Provincial Governments bonds offer high quality and better rates than similar Government of Canada bonds. They pay a guaranteed, fixed level of interest income and are also available for terms from one to 30 years. Provincial Bonds issues are typically expressed as a spread over the Government of Canada bond yields. Some five-year provincial bonds yield 4.17%, nine-year 4.97%, eleven-year 5.11% and 25-year 5.51%[5]. In 1999, Standard and Poor's upgraded Newfoundland and Labrador's long term issuer credit rating to A minus from triple B plus.

The Standard and Poor's also upgraded its long-term senior debt ratings on the Province and on Newfoundland and Labrador Hydro (NLH) to A minus. NLH has consistently issued bonds in the last decades. NLH's bonds issued between 1989 to 1992 yield 10.25%, and bonds issued after 1992 yield between 5.05% and 8.40% depending on their year of maturity.

Newfoundland and Labrador's GDP growth was taken into consideration for the rating upgrade established by Standard and Poor's. In the next couple of years, Newfoundland and Labrador's GDP is expected to continue growing at a slower pace[6]. This upgrade enhances the ability of the province, and its Crown corporations, to access the financial markets on more favourable terms and at lower interest rates. Among other indicators Newfoundland inflation is expected to increase at some 1.9% annually until year 2007[7].

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[3] *Bank of Canada*

[4] *Department of Finance Canada*

[5] *Edward Jones Investments: http://www.edwardjones.com*

[6] *Newfoundland and Labrador Department of Finance*

[7] *Newfoundland and Labrador Department of Finance*

8.2 Financial Analysis

Selection of Key Target Parameters

Based on the preceding discussion, the following key parameters are selected for use in the financial analysis.

The long-term inflation rate of 2.5%, and nominal and real social discount rates of 10% and 7.5% respectively have been introduced previously and employed in the economic analysis reported previously.

For purposes of examining debt financing, the rate employed for the base case is 8% real (10.5% nominal), to be applied in amortization calculations over the operating life of 30 years, and including a risk premium because of the nature of the project. Short-term debt to finance construction work is estimated on the basis of 5%.

From the discussion above, if the project were to involve equity participation, then an acceptable long-term equity return would be 22.5% pre-tax. This is based on after-tax return on equity of 13.5% (high end, with risk premium), assuming an effective corporate tax rate of 40%. If a project were to be financed 25% with equity, then the blended target rate of return would be 13.5%. If the debt rate were to be reduced by 2%, then the blended target rate of return would drop to 12%.

At this pre-feasibility stage of the project, it is considered that these parameters are more or less in line with the risk and reward expectations of prospective investors. In other words, internal rates of return below 12% are not likely to attract private capital without significant external favourable considerations.

It is clear that the project in its entirety is incapable of even approaching this target. However this is useful to keep in mind in respect of a strategy that would segment the costs and risks to privatize a portion of the project. For example, if the project were to be built with public financing, then the operation could be submitted to tender or some other competitive process to franchise it for pecuniary considerations. The pricing for this would be influenced by the target returns from operations.

Financial Analysis Results

The first order of business is to translate the constant dollar estimates for project costs and revenues into nominal values. In carrying out this conversion, the cost of financing during construction is also determined by calculating interest on: current year costs plus previous year payments plus interest accumulated in prior years. The project costs translated into current dollars, representing the total cost of the project are shown in Table 8.3 for both the longer and a quicker construction periods.

Table 8.3 Project Capital Cost Summary

	BASE CASE	**HVDC**
	$ Millions	**$ Millions**
Total Cost - Constant $2004	$1,184	$1261
Total Cost - Current $	$1,450	$1550
Interest During Construction	$257	$263
Total to Finance	$1,708	$1813

The first conclusion that becomes evident is the total project costs are approximately 50% higher on account of inflation and interest expense -- $1.7 billion versus $1.2 billion. The advantage of a quicker construction phase is also now apparent, because a slight cost disadvantage in constant dollar terms becomes an advantage in real world conditions. The swing overall is worth $100 million. This is the reason for preferring the Two TBM process.

The total amount to finance is $1,708 million. Incorporating the post operation cash flows, the Internal Rate Of Return is –9.3%. This remains consistent with the conclusion of the economic analysis, that the project is not bankable on its own merits. There is no point in proceeding without access to free capital that might be made available to suit some higher purpose. Debt financing of this amount would create a situation in which losses perpetually accumulate and compound.

With a view to identifying a set of financial conditions under which the project could proceed, various scenarios involving grants or contributions were considered. The main finding is that a total contribution in the order of $1.4 billion, or more, would be required for the project to be self sufficient.

To illustrate the impact of this point, a grant of $1.395 billion could be dispersed over nine years to cover planning, design and most of the construction. This has been calculated at about $60 million in total over the initial 5-year stage for planning, approval and design, and between $250 and $300 million per year over each of the next four years during construction. While this money is being dispersed as needed to cover current costs, interest expense is avoided. The amount to be financed as a result of this would be about $50 million, including interest. This contribution level, was determined such that the project cash flows could provide a return around 8%. This is still below the private finance threshold considered applicable at this time, except perhaps for long-term debt, but it is close enough to illustrate the level of public support that is a prerequisite for advancing the project.

Once the appropriate level of support is decided, then the models developed for this project could be employed to explore more variations and to examine revenue and cost relationships. Without any public support, there is not sufficient justification to advance from here. The issue of public sector involvement is thus identified as a fundamental condition to resolve for advancing beyond the present pre-feasibility stage.

The larger scope issues include significant benefits that extend beyond the terms of reference, resources or time available for this project. Nevertheless, these were mentioned as important issues during consultations with outside interested parties. They include:

- Benefits to travellers and freight shippers not measured by toll revenues
- Energy price and supply impacts of HVDC e.g. industrial growth opportunities;
- Social factors attributable to a permanent fixed link between Newfoundland Island and Labrador;
- Hwy 138 in Quebec extension to the tunnel.

High prices for electrical energy in Newfoundland have been cited as a deterrent to industrial growth and a major potential benefit of a fixed link. While transportation benefits of the fixed link are anticipated by users to be significant, the primary motivation for increasing business opportunities and employment in the resource and small manufacturing sectors of the Great Northern Peninsula and Labrador is to bring power across from Labrador hydro developments and thus ensure long-term stability in the supply and price of

electrical energy. This, of course, is a positive feature that is intimately connected to justification of the tunnel.
The benefits from such new developments would not necessarily be internalized in the tunnel projections, because the fixed link across the Strait of Belle Isle is just a small part of the total transmission system that would be built to support such developments. Analyzing this potential is a major undertaking on its own. Proponents of the fixed link make a case for these advantages. Considering current trends in prices for fossil fuels and the prospect of crude oil above $50/barrel continuing, there appears to be merit for these arguments at face value, and the beneficiaries would be the population at large.

Social factors attributable to a permanent fixed link are important considerations more closely linked to the visionary goals and objectives of the population as interpreted by the Government. They are beyond the scope of a quantitative analysis such as this project.

Finally, all of the projections contained in this study are founded on the assumption that there would be a continuous road link from Québec City to the tunnel portal along the North Shore of the Gulf of St. Lawrence. Such a project has been under consideration and preliminary estimates are reported elsewhere in this document. It is unlikely that there would be a significant growth in long-distance travel to the crossing if this route were not completed. The Trans-Labrador highway, once completed, is such a long detour that it would discourage most prospective drivers. It would thus be prudent to ensure that Highway 138 in Quebec will be built before finalizing any financial or economic justification of a transportation fixed link between the Island of Newfoundland and Labrador.

9 CONCLUSIONS

9.1 Study Findings

Of the various concepts addressed in this study to provide a fixed transportation link between Labrador and the Island of Newfoundland, a tunnel bored under the Strait of Belle Isle, at its narrowest point, is the most technically and economically attractive. A bridge or combination of causeway and bridge would be subject to very large construction and operating risks because of the challenging physical environment and would have very high capital costs. Additionally these structures could have adverse effects on the oceanography and climate of the study area. A tunnel would not be subject to the same environmental constraints.

Of the three tunnel concepts studied, a drill and blast tunnel would be more difficult to seal against water ingress and would be longer than a bored tunnel due to its greater depth; an immersed tube tunnel would be exposed to high risk from iceberg scour which would have to be accommodated through expensive ditching in bedrock or massive protection works. A tunnel created by using modern tunnel boring machines, on the other hand, with their superior water sealing capacity would allow placement at a higher level in the bedrock and consequent shorter length than in the case of a drill and blast tunnel.

The construction cost of a bored tunnel would be approximately $1.2 billion in 2004 dollars. The total development cost for financing purposes, including escalation and interest during construction would be approximately $1.7 billion. The construction period would be six years and an additional five years would be required for planning, additional studies and investigations and environmental assessments for an overall development period of 11 years.

Based on traffic projections over a 30 year period, the most economic tunnel arrangement would be an electric train shuttle, operating through a single tunnel with staged operation in each direction that conveys road vehicles on custom-designed rail cars. A rail tunnel results in a much smaller cross-section from that required in a road tunnel due to reduced ventilation requirements.

The economic and business case analyses were carried out for three scenarios:

- A base case for a fixed link for transportation only
- An upgraded ferry case providing increased level of service
- The base base augmented by revenue from the installation of a HVDC cable in the tunnel.

The analyses, developed by considering traffic diversion from existing services, growth in service and facility demands, the impact of both construction and operating jobs, and the inclusion of potential revenue from incorporating electrical transmission cables in the tunnel, showed that a fixed link would not attract private sector financing under normal economic and business case criteria. Using relatively optimistic diversion and growth assumptions resulted in negative rates of return and less than unity cost benefits ratios over the period of the study. This result, however, may be considered not atypical in the realm of public transportation infrastructure.

The upgraded ferry option, while not providing the same level of service, is a lower capital cost alternative but would require an annual subsidy financing approach to the crossing.

Including costs and revenue for the transmission lines has an effect on the overall viability of the fixed link. Incorporating the HVDC cables in the fixed link rather than constructing a submarine installation, reduces the capital cost to an HVDC proponent by approximately $390 M. This cost reduction includes the cost of the cable, for which a rental would be charged by the fixed link proponent.

Of the financing methodologies addressed, some form of PPP (Public Private Partnership) arrangement would appear to be the most appropriate. An infusion of approximately $1.4 billion from public sources would be required to make the proposition attractive to the private sector.

A review of the potential impact of industrial development in Labrador on the use of the fixed link concluded that of four industries – mining, forestry, offshore gas, and hydroelectricity - only the last was likely to have a significant potential benefit. In addition to the benefit derived from being able to incorporate high voltage transmission cables into a fixed link, one could make an argument that an overall hydroelectric development on the Lower Churchill, and possibly other rivers in southern Labrador, could lead to industrial development (such as aluminium smelting) in the area. Locating such a capacity in the vicinity of the fixed link terminus on the Labrador side would be more or less synergistic with the overall objective of government of physically linking the two parts of the province, providing electrical power to the Island from sources in Labrador, and providing an opportunity for social and economic success in northern Newfoundland and Labrador.

9.2 Future Required Activities

In order to progress the study to a full feasibility study and environmental assessment, the following activities would be required:

- Further geotechnical investigation along the proposed alignment. For the feasibility study, this would include the first stage of a two-stage borehole investigation within the Strait. This investigation would be costly due to the water depths involved. The expected cost would be of the order of $10 million. The second stage of the borehole investigation would be undertaken later, in the detailed design period, and could cost up to $20 million.
- Investigation of the ambient environmental conditions particularly along the two shorelines and within the proposed terminus areas.
- Further refinement of traffic projections. This would involve the execution of an origin/destination survey and additional tourism surveys. Considering the relative lack of sensitivity to traffic demand shown for this facility, these surveys may be deemed unnecessary. However, a full environmental assessment may require these surveys.
- Investigation of activities required for a full environmental assessment including public involvement and impact analyses.

The total cost of a full feasibility/environmental assessment study would therefore vary according to the content, certain aspects are essential and are as follows:

•	Phase 1 geotechnical investigation allowance for this activity	$10.0 million
•	Environmental data collection	$0.5 million
•	Study Engineering Scope	$0.5 million
•	Full environmental assessment	$4.0 million
	Total	$15.0 million

Other activities are considered either optional or may be defined in a separate study as follows:

• Surveys for traffic projection	$0.5 million
• Economic Analysis	$0.3 million
Total	$0.8 million

The cost estimates presented in this report are to an estimate accuracy ±30%. The result of undertaking the above noted feasibility/enviromental assessment studies would be that the estimate accuracy would be improved to ±20%.

APPENDIX A

STUDY PHASE 1 - LIST OF REFERENCES

Appendix A
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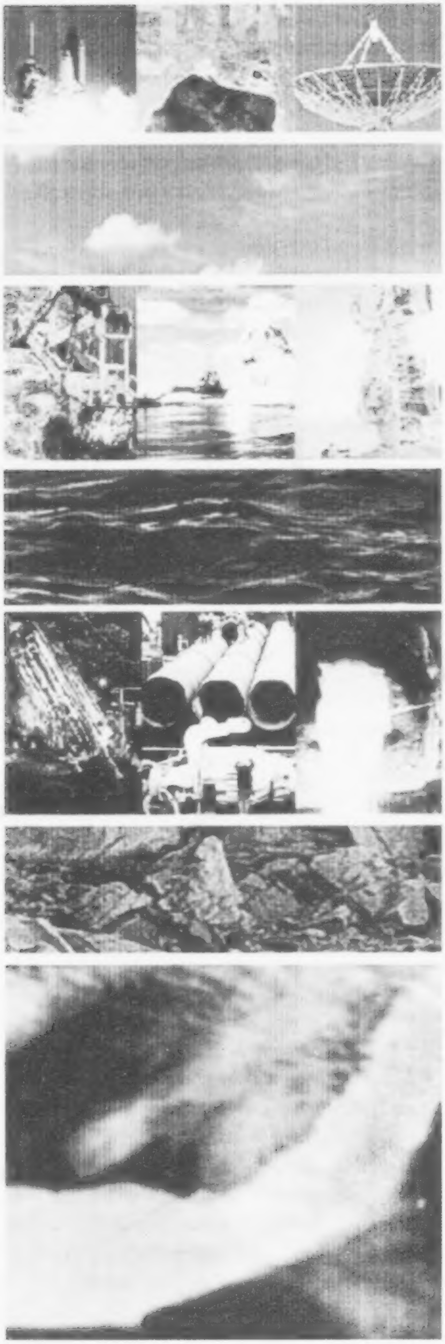

Iceberg Scour Risk in the Strait of Belle Isle

April 2004
C-CORE Report R-04-004-011

C-CORE

Iceberg Scour Risk in the Strait of Belle Isle

Version 1

Prepared for:
SGE Acres Limited

Prepared by:
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C-CORE Report:
R-04-004-011

April 2004

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Tony King

EXECUTIVE SUMMARY

Iceberg scour risk and required cover depths were determined for a proposed tunnel crossing in the Strait of Belle Isle running from Yankee Point to Pointe Amour. Grounding rates were determined using a grounding model that uses the mean iceberg drift speed, iceberg keel depth distribution, iceberg frequency, water depth and seabed slope.

Iceberg drift speed was based on 21 iceberg trajectories collected off Pointe Amour. Iceberg frequency was determined from an analysis of Canadian Ice Service iceberg charts from 1988 to 2004. Iceberg keel draft distribution was based on observed iceberg waterline length data collected off the coasts of Newfoundland and Labrador. Water depth and seabed slope were determined using data from a bathymetric chart.

The results of the grounding model were then used to determine iceberg risk using iceberg scour and pit data from the White Rose region of the Grand Banks. Required clearances between scouring and pitting iceberg keels were based on pipeline risk analyses from the same site. The required cover depths over the top of the tunnel as a function of the mean return periods between damage events are shown on Figure 1. Required cover depths are on the order of 3 to 5.5 m for return periods of 100 and 1000 years, respectively, to prevent damage from scouring and pitting icebergs. A preliminary investigation indicates that bathymetric shielding is unlikely to have a significant effect on overall cover depth requirements.

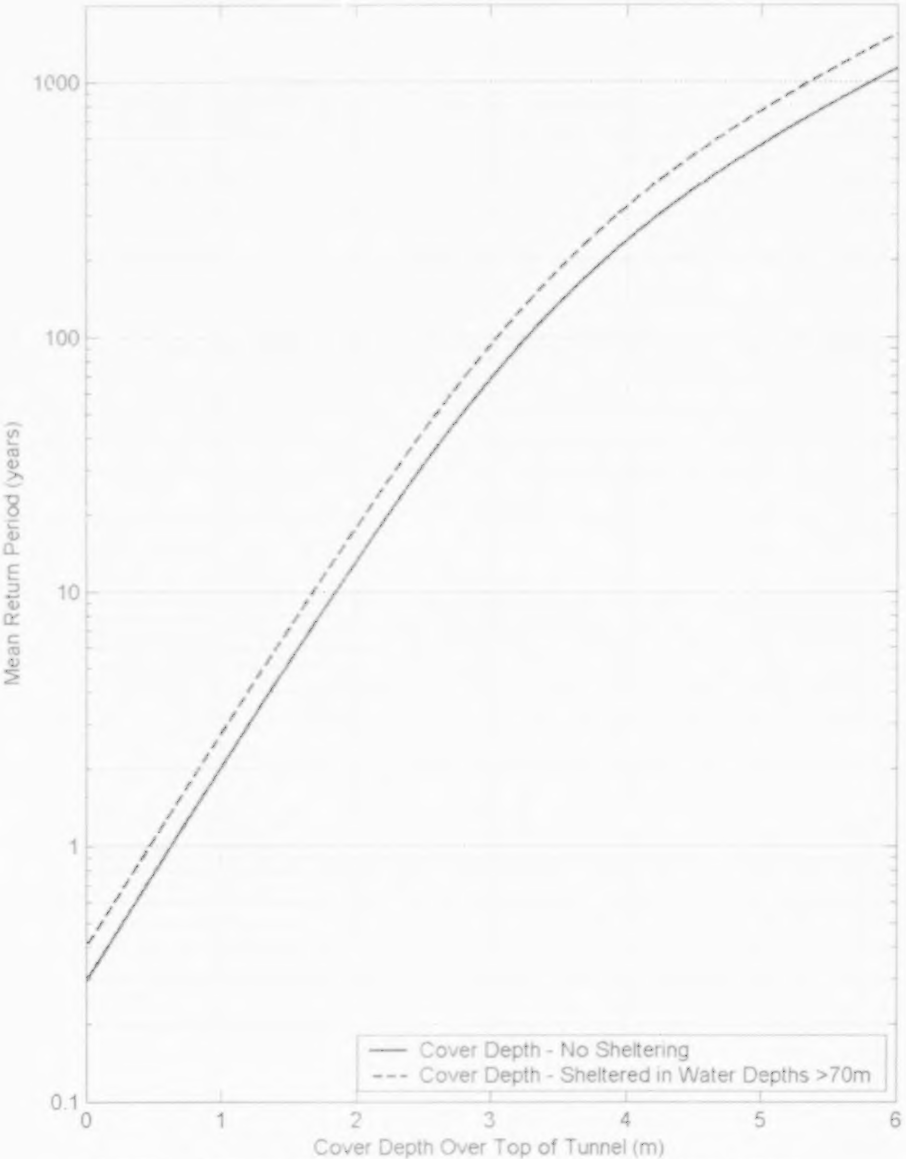

Figure 1. Required cover over top of tunnel to prevent iceberg damage.

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1 INTRODUCTION

1.1 Background

The origin and movement of icebergs off eastern Canada are generally well understood. For the purposes of this study, the concerns are with the potential for scouring and collision with bottom founded structures. Scours are a concern with only an immersed tunnel concept that would have shallow burial.

A number of studies were done on the scour question in the 1970's and early 1980's in consideration of a submarine transmission cable from the proposed Lower Churchill development. A fundamental question relates to the potential for scour southwest of a 70 m shoal that is 45 km upstream of the proposed crossing line. This subject is discussed at length in Woodworth-Lynas et al. (1992) and will be addressed in this report.

Approximately 10-15% of the icebergs that pass the latitude of the Strait of Belle Isle drift into the Strait, with the largest number been seen in May and June. Most of these enter on the Labrador side and exit on the island of Newfoundland side in concert with the prevailing currents. A few of these icebergs move into the Gulf and ground along the Quebec shore (a few have been known to penetrate to Anticosti Island or the Bay of Islands area, with one small iceberg reaching the Cabot Strait in 1960 before melting). The greatest number of icebergs observed in the Strait of Belle Isle at one time was 496, recorded by the Belle Isle lighthouse keeper on May 30, 1858.

The shoal area previously mentioned was thought to act as an iceberg filter and prevent any deeper icebergs from drifting into the proposed cable crossing area. However, scours in deeper water further into the Strait have been observed thus causing one to question this theory. A number of researchers have postulated that because icebergs roll, the previous draft may increase thereby permitting the iceberg to contact the seabed in water deeper than 70 m. Risk analysis studies commissioned as part of the Lower Churchill program suggested that the probability of an iceberg scouring along the proposed cable route is 0.5 events for every 100 icebergs in water depths greater than 75 m and 0.1 events per 100 icebergs in water depths greater than 85 m. In engineering studies of the cable crossing, the concept was to trench and bury the cable to a water depth of 85 m.

While there is some doubt about the risk associated with scour, there is also no data on the depth of scour in the area, thus making a recommendation of scour depth difficult. However, there is such data from other areas and reasonable extrapolations are possible.

In recent years, significant work has been done on the subject for the protection of seabed equipment on the Grand Banks.

For the purposes of the current study, the risk of scour in the Strait was analyzed using the most recent work by researchers at C-CORE and a design burial depth was determined. A description of this analysis follows.

1.2 Objectives

The objectives of this report were:

- to estimate the frequency of scour crossing events over a proposed "fixed link" option (consisting of a prefabricated concrete tunnel placed in a trench and backfilled) connecting Newfoundland and Labrador, and
- to estimate the required cover (distance from mudline to top of structure) required to prevent damage due to iceberg scour for a range of return periods.

2 GROUNDING MODEL

2.1 Background

A number of techniques have been used to estimate iceberg scour rates on the Grand Banks. These techniques include those based on repetitive mapping, seabed scour density, iceberg trajectories, sedimentation rates, sediment mobility and numerical models. A number of sites on the Grand Banks have been repeatedly surveyed in order to determine the number of new scours formed. The results of these repetitive mapping surveys have been analyzed using both Monte Carlo modeling (C-CORE, 2003) and statistical approaches (C-CORE, 2004), allowing the distribution of possible scour rates in the area to be defined. Lewis et al. (1988) suggested, based on data obtained from the analysis of sediment cores, that "modern" scouring began on the Grand Banks about 2500 years ago with the strengthening of the inner branch of the Labrador Current, allowing scour rates to be estimated by dividing the observed seabed scour density by 2500. Banke (1989a,b) developed an approach for analyzing iceberg drift tracks to determine iceberg grounding frequencies on the northeast Grand Banks. Gaskill et al. (1985) used observed scour densities and inferred sedimentation rates to estimate scour rates for three sites on the Grand Banks. Amos and Barrie (1982) used the density of scours observed in a megaripple field near Hibernia and the estimated time since these features were last reworked by a storm to calculate scour rates for the area. Numerical models (d'Apollonia and Lewis, 1986; King et al., 2003) have also been developed to estimate iceberg grounding rates based on iceberg frequency, draft distribution, drift and bathymetric data.

With the exception of numerical models, these approaches for estimating scour rate depend on field data that are not available for the Strait of Belle Isle. No repetitive mapping has been performed and insufficient seabed mapping exists to get a reliable measure of seabed scour density. Additionally, the high current speeds in the area would likely result in relatively rapid infilling of scour features, which would render both of these approaches useless for estimating scour rate. Trajectory analysis also cannot be used due to the limited available data. Likewise, approaches based on sedimentation or seabed processes are not applicable due to limited data. However, the data required for a grounding model (iceberg density, drift speed, keel draft distribution and bathymetry) are available and may be used to estimate grounding rates.

2.2 Derivation of Grounding Model

Figure 2-1 depicts iceberg keels with sufficient draft to impact the seabed and an areal density ρ_k drifting with a mean drift speed $\overline{U}$ towards a section of seabed of width W. In the case where the icebergs are drifting in a direction normal to the bathymetric contours, the frequency, f_g, at which iceberg keels impact, or ground on the seabed is:

$$f_g = \rho_k \overline{U} W \tag{2.1}$$

Iceberg keels grounding in adjacent sections of seabed are not considered, even if some small portion of the keel extends over the boundary. This distinction is made to avoid double counting of grounding events and to make the solution independent of the width of the specified section of seabed. Figure 2-1 shows the influence of the relative orientation between the seabed slope and the iceberg keel drift direction. If the orientation is changed by some angle θ, then the size of target presented to the keels is reduced and the iceberg keel grounding frequency is:

$$f_g = \rho_k U W \cos(\theta) \tag{2.2}$$

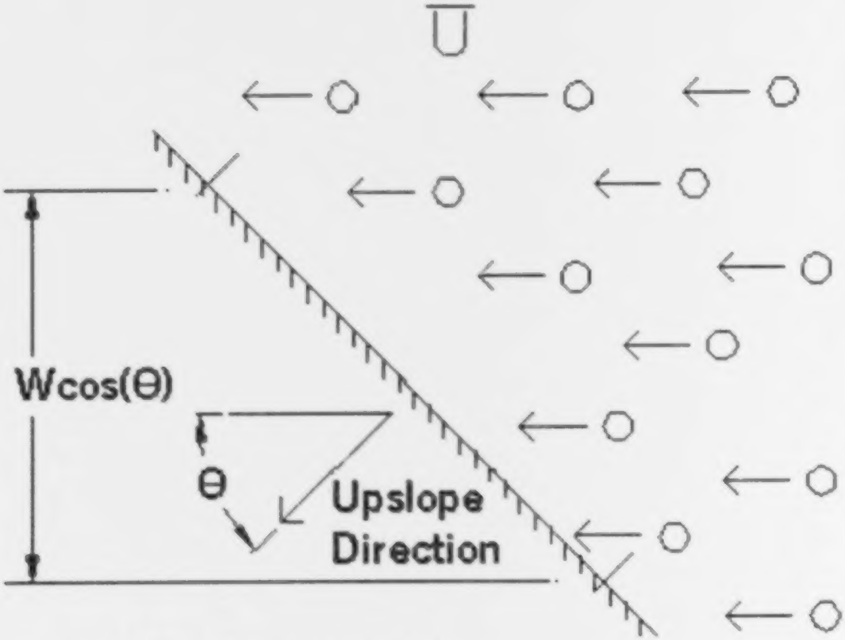

Figure 2-1 Iceberg keels approaching seabed.

Thus far, consideration has been given only to the density of iceberg keels capable of striking the seabed. However, the available data only give the density of icebergs that can be observed on the surface, n_o (with icebergs with waterline lengths < 16 m excluded). The number of icebergs that can strike a section of seabed covering a specific water depth range is limited to those with drafts in this depth range. Icebergs with lower drafts will ground in shallower water (if at all) and icebergs with greater drafts will ground in deeper water depths. A reduction factor (r_d), equal to the proportion of icebergs with drafts in the appropriate depth range (units: m^{-1}) was applied to the iceberg density to account for this effect, giving:

$$f_g = n_o r_d \overline{U} W \cos(\theta) \tag{2.3}$$

where θ is the orientation of iceberg drift direction relative to the upslope direction. The range of drift direction that needs to be considered is ± 90° relative to the upslope direction. If the drift direction relative to the upslope direction exceeds ± 90° then the iceberg is drifting down-slope and will not ground, unless it undergoes some draft change due to rolling or calving. This latter effect was ignored in this formulation. To calculate the total grounding frequency it was recognized that the mean drift speed usually varies with drift direction and that the distribution of drift direction is not uniform. An additional term, r_θ, was introduced to specify the proportion of time that icebergs drift in a specified direction. This allowed the total grounding rate to be expressed as:

$$f_g = r_d n_o W \int_{-\pi/2}^{\pi/2} r_\theta(\theta) \overline{U}(\theta) \cos(\theta) d\theta \tag{2.4}$$

Thus far, no consideration has been given to the seabed slope or the proportion of iceberg keel to be considered for grounding. Figure 2-2 shows a square sample section of seabed with a dimension W parallel and perpendicular to the seabed isobath and with a slope of S. The sample seabed section was defined on the basis of a 1 m rise, so $S=1/W$ and, except for extreme slopes, the area of the seabed section was considered to be W^2 or $1/S^2$ (the error is less than 5% for a slope of 30%). The frequency of groundings, f_g, was expressed in terms of grounding rate per unit area, ρ_g, as follows:

$$\rho_g = r_d n_o \frac{W}{A} \int_{-\pi/2}^{\pi/2} r_\theta(\theta) \overline{U}(\theta) \cos(\theta) d\theta \tag{2.5}$$

where r_d is now more specifically defined as the proportion of iceberg keels in a 1 m increment above the seabed. Expressing W and A in terms of slope gives:

$$\rho_g = r_d n_o S \int_{-\pi/2}^{\pi/2} r_\theta(\theta)\overline{U}(\theta)\cos(\theta)d\theta \qquad (2.6)$$

If directional drift data are available, Equation (2.6) can be evaluated using numerical integration. Alternatively, when directional drift data are not available, a non-directional form of Equation (2.6) can be used. By assuming a mean drift speed that is independent of direction and a uniform distribution of drift direction ($r_\theta = 1/2\pi$), Equation (2.6) can be integrated over the prescribed limits to yield:

$$\rho_g = \frac{1}{\pi} r_d n_o S\overline{U} \qquad (2.7)$$

Since the available iceberg drift data in the Strait of Belle Isle are limited and not suitable for generating mean drift speeds as a function of drift direction, iceberg grounding rates will be estimated using Equation (2.7).

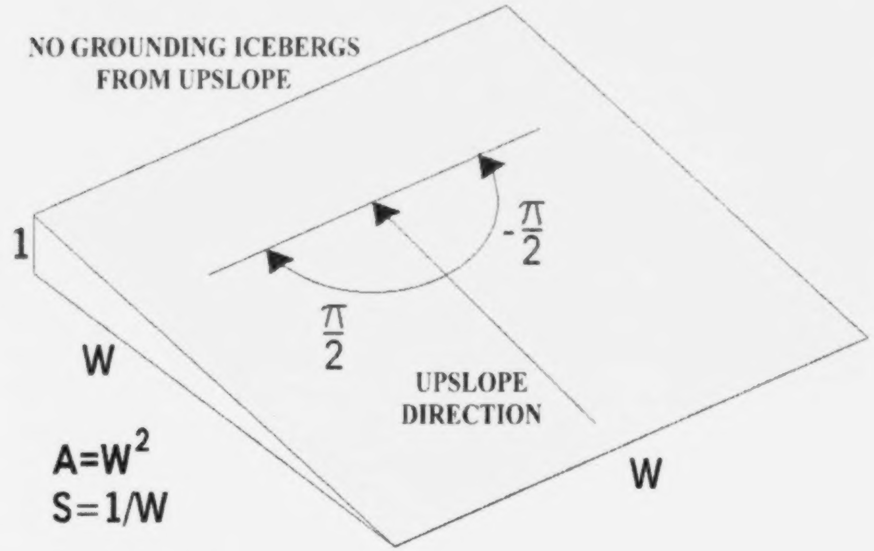

Figure 2-2 Geometry of unit area of seabed (from King et al., 2003)

2.3 Grounding Model Input

2.3.1 Iceberg Frequency

Iceberg frequency is expressed in terms of areal density, which is the average number of icebergs in a given area (typically a degree square) at any given instant in time, averaged over a long time period. The most reliable source of iceberg sightings on the Grand Banks in terms of frequency and coverage of surveys is the International Ice Patrol (IIP). However, IIP coverage of the Strait of Belle Isle is infrequent so iceberg charts issued by the Canadian Ice Service (CIS) were analyzed to determine iceberg frequency. A total of 481 charts were analyzed, covering a period from May, 1988, to April, 2004. Figure 2-3 shows the resulting average annual iceberg areal density per degree square for the Strait of Belle Isle and the adjacent degree squares. Iceberg density expressed on a degree square basis can be converted to density per square kilometer as follows:

$$n_o\,(km^{-2}) = n_o\,(degree^{-2}) \,/\, (\cos(\phi)\times 1.237\times 10^4) \qquad (2.8)$$

where ϕ is degrees latitude. Therefore, the average iceberg density for the Strait of Belle Isle degree square is 1.25×10^{-3} km^{-2}. However, approximately 70% of the degree square in question is covered by land (with icebergs limited to the remaining portion), therefore the actual iceberg density (used for risk calculations) is 4.1×10^{-3} km^{-2}. This is approximately 40 times higher than the iceberg density in the Jeanne d'Arc region of the Grand Banks.

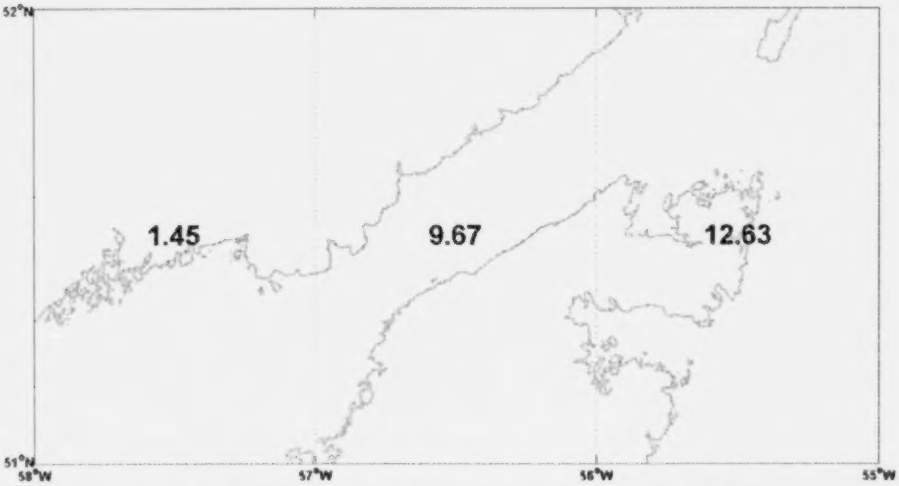

Figure 2-3 Annual average iceberg density per degree square for study area.

2.3.2 *Iceberg Drift Speed*

A limited amount of iceberg drift data has been collected in the study area. In 1979 and 1980, iceberg trajectory data were collected for 21 icebergs using a X-band marine radar mounted on the Pointe Amour lighthouse, at an elevation of approximately 43 m (Roche, 1980). These data are shown in Figure 2-4. The distribution of drift speed (excluding periods where the icebergs were grounded) is shown in Figure 2-5. These data are appropriate for determining the kinetic energy of icebergs during collision events, however due to the fact that icebergs in this area frequently ground for extended periods, the overall mean drift speed (including grounded intervals) is 0.12 m/s. This is the appropriate drift speed for calculating grounding rates.

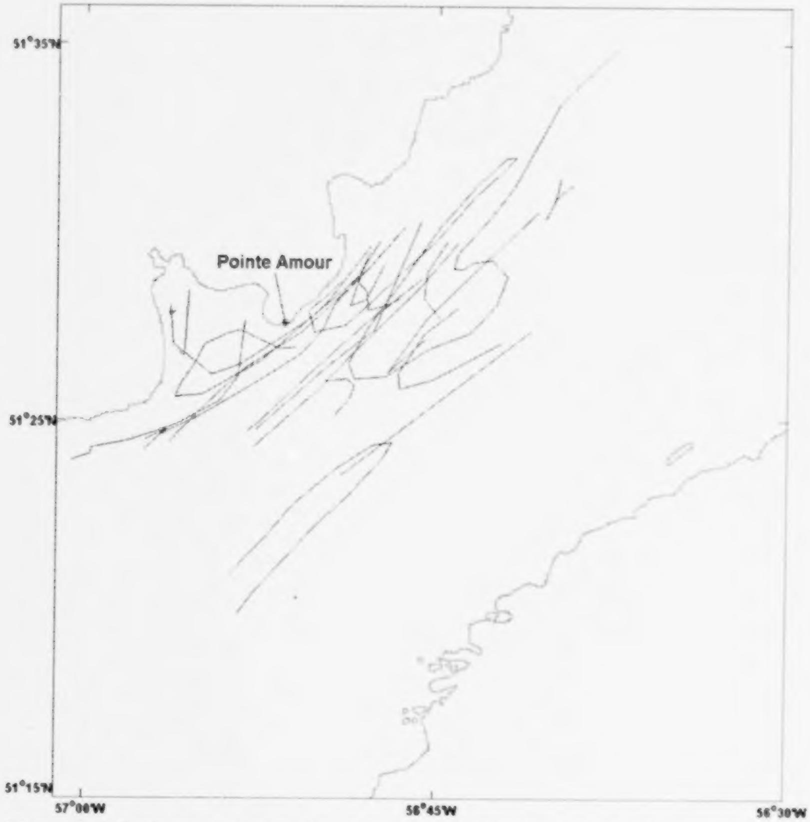

Figure 2-4 Iceberg drift track data from Strait of Belle Isle (Roche, 1980).

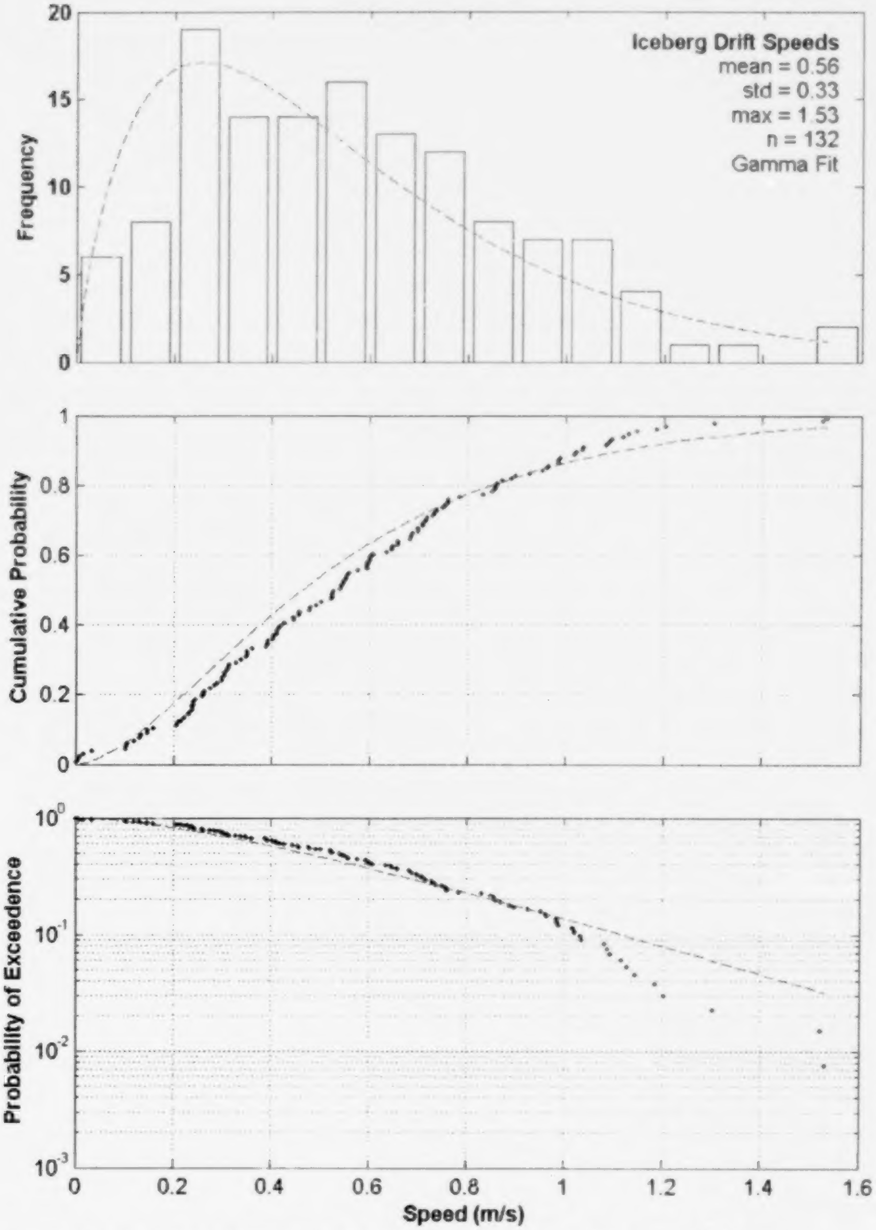

Figure 2-5 Iceberg drift speed in Strait of Belle Isle, excluding grounded icebergs.

2.3.3 Iceberg Keel Draft Distribution

The iceberg waterline length distribution on the Grand Banks follows an exponential distribution with a mean of 59 m (Jordaan et al., 1995). While icebergs numbers are much greater off the coast of Labrador, the available data indicates the distribution of iceberg lengths is roughly the same (King, 2002). Iceberg surveys have resulted in 211 iceberg length/draft measurements off the coast of Newfoundland. In order to relate iceberg waterline length to draft the following equation was derived (King, 2002):

$$D_i = \exp(\ln(3.23) + 0.68 \ln(L_i) + N(0,0.25)) \tag{2.9}$$

where D_i is iceberg draft and L_i is waterline length. The scatter in the original data set is simulated using $N(0,0.25)$, which is a normally-distributed random variable with a mean of 0 and a standard deviation of 0.25. A large sample of waterline lengths, exponentially distributed with a mean of 59 m, was generated and the corresponding drafts were calculated using Equation (2.9). Waterline lengths less than 16 m were excluded since areal density values exclude these icebergs. The proportion of iceberg keels per metre of the water column is shown in Figure 2-6.

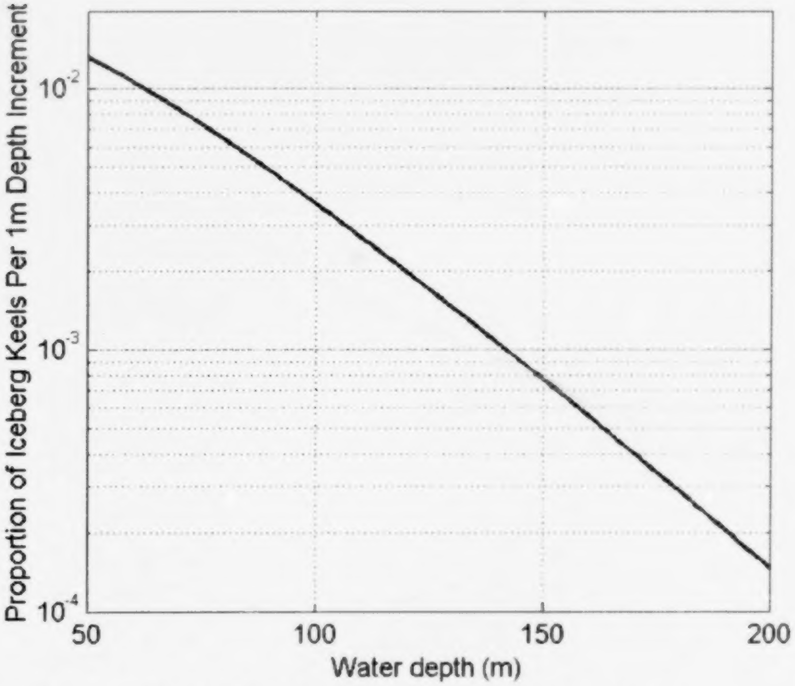

Figure 2-6 Iceberg keel draft distribution (from King et al., 2003).

2.3.4 *Bathymetry*

Bathymetric data were required to determine water depth and seabed slope. Bathymetry data were manually digitized from a scanned version of CHS Chart 4020. The resulting dataset was put on a grid with a 0.005° latitude and 0.005° longitude resolution. The resulting data, plotted as a filled color contour plot, are shown in Figure 2-7. This figure also shows the location of the proposed tunnel crossing (dotted line) and the sill to the northeast, which is thought to offer some shielding from iceberg keels for certain water depths. This data set was further processed to give seabed slopes. The average seabed slope in the area shown in Figure 2-7 is ≈1%, approximately 10 times greater than on the northeast Grand Banks.

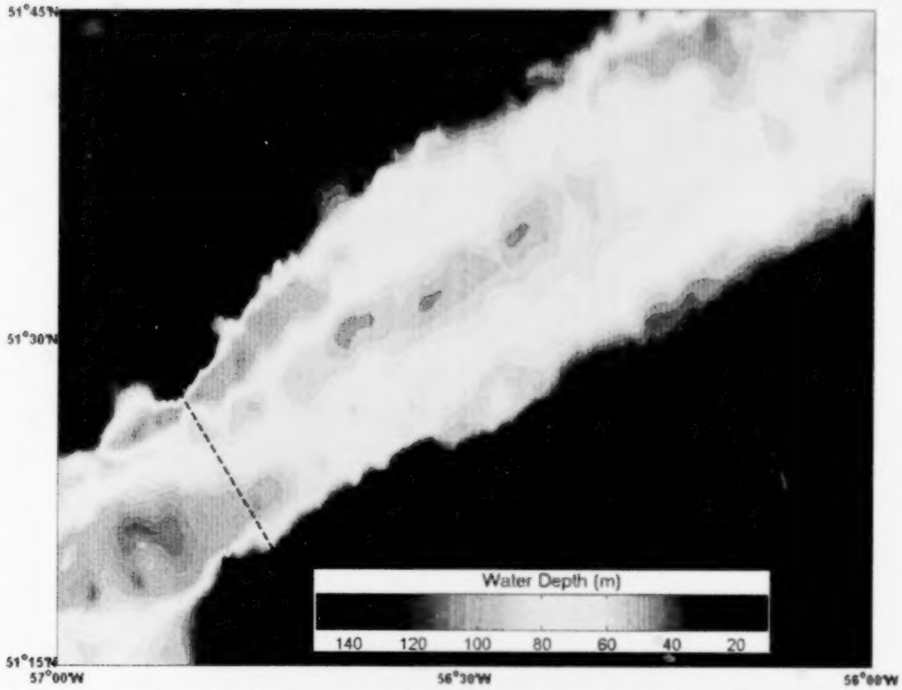

Figure 2-7 Bathymetry for study area, showing tunnel route (dotted line).

2.4 Modeled Grounding Rate

Figure 2-8 shows grounding rates modeled using Equation (2.7). These grounding rates apply only to icebergs with waterline lengths ≥ 16 m. Smaller icebergs (bergy bits and growlers) will ground in shallower water close to shore, but are unlikely to pose a significant hazard. It can be seen that the highest grounding rates are predicted relatively close to shore where seabed slopes are relatively steep in the 30-60 m water depth range.

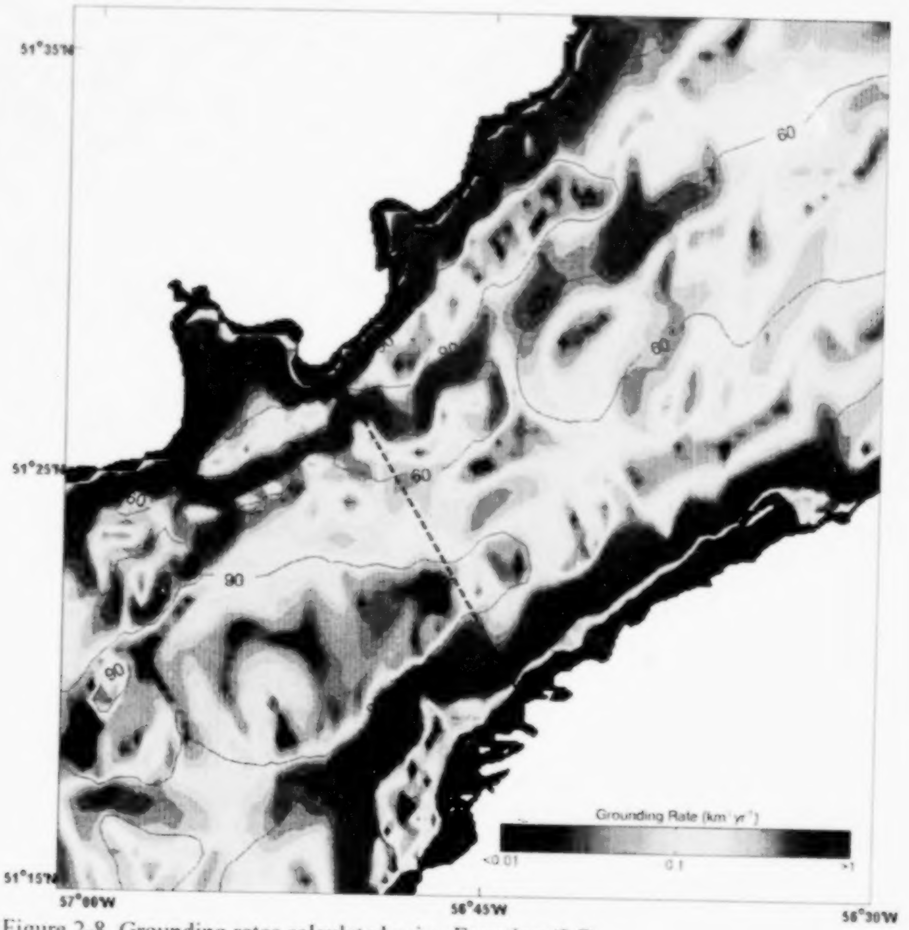
51°35'N
51°25'N
51°15'N
57°00'W
56°45'W
56°30'W
60
60
60
60
90
90
90
90
Grounding Rate ($km^{-1} yr^{-1}$)
<0.01
0.1
>1

Figure 2-8 Grounding rates calculated using Equation (2.7).

3 SCOUR RISK

3.1 Methodology

The risk analysis methodology is broken down into three basic steps:

- interpolate the grounding rate along the proposed tunnel route;
- convert the grounding rate into scour and pitting rates and using scour/pit geometric data, calculate crossing events over the tunnel route; and
- determine the number of pitting/scouring events occurring over the tunnel with the potential to cause damage, based on cover depth, pit/scour cover depth and the acceptance criteria.

3.1.1 Scour Data

There is insufficient site-specific scour data for use in the tunnel risk analysis. Therefore, it is necessary to rely on scour data (here collectively refering to both scours and pits) collected elsewhere. Scour features can be broken down into scours (long furrows) and pits (circular or oval features), and both of these types of scour features have different shape and depth characteristics. C-CORE (2001a,b) documented iceberg scour parameters for the White Rose region and these data, given in Table 3-1, will be used here for the risk analysis. The corrected scour length given in Table 3-1 accounts for the truncation of scours at the edge of seabed survey. Approximately 10% of the scour features observed at White Rose were pits. Both scour and pit depths are considered to follow an exponential distribution.

Table 3-1 Iceberg Scour Parameters at White Rose (from C-CORE, 2001b).

Parameter	**Mean**	**Standard Deviation**	**Maximum**
Measured Scour Length	588 m	784 m	10710 m
Corrected Scour Length	*650 m*	-----	-----
Scour Width	24.9 m	14.4 m	----
Scour Depth	0.34 m	0.30 m	2.5 m
Average Pit Dimension	57.0 m	37.2 m	199 m
Pit Depth	1.1 m	0.9 m	5.2 m

3.1.2 Crossing Rates

The annual number of scours occurring over the tunnel (or subsection of tunnel) can be calculated following the approach described by Astafyev et al. (1997) as follows:

$$N_s = \frac{2}{\pi} f_{sc} L_T \overline{L}_s \tag{3.1}$$

where f_{sc} is the scour rate, L_T is the length of the tunnel (or section of tunnel) $\overline{L}_s$ is the mean scour length (650 m). Likewise, Equation (3.1) can also be used to calculate the annual frequency of pit features, N_p, occurring over the tunnel by substituting f_p (pitting frequency) for f_s and substituting the mean pit width (55 m) for the mean scour length. This approach assumes a uniform distribution of scour direction.

3.1.3 Acceptance Criteria

There is insufficient data to perform an analysis of the response of the tunnel to scour and pit events, therefore it is necessary to rely on other work. In order to limit distress in the structure an acceptance criteria (using a minimum distance between the bottom of a scouring or pitting iceberg keel) was established. At White Rose, a sub-scour clearance equal to half the scour depth was sufficient to prevent damage (C-CORE, 2001b) to a trenched pipeline. For a 2 m deep scour this means that an additional clearance of 1 m would be required to prevent damage, for a total cover depth of 3 m. Although a detailed analysis has not been performed for pitting icebergs, the same criteria will be applied. These criteria are reasonable, however it is expected that for any follow-up work a detailed analysis would be performed for a tunnel structure once sufficient scour, soil and structural data are available.

The annual number (N) of iceberg scour features (scours and pits) penetrating deep enough to exceed the acceptance criteria (i.e. cause damage) to the tunnel can be calculated, following the approach outlined by Pilkington (1986), using:

$$N = N_s e^{-2C/3\overline{D}_s} + N_p e^{-2C/3\overline{D}_p} \tag{3.2}$$

where N_s and N_p are the annual number of scour and pit features crossing over the tunnel, C is the tunnel cover depth (top of tunnel to mudline), and $\overline{D}_s$ and $\overline{D}_p$ are the mean scour and pit depths.

3.2 Risk Analysis Results

Figure 3-1 (top) shows the water depth along the proposed tunnel route from Yankee Point to Pointe Amour. The maximum water depth along the route is 94 m. Figure 3-1 (bottom) shows the annual frequency of scour and pit events along the tunnel route. As would be expected from the results shown in Figure 2-8, the majority of events occur on the steep slopes on either side of the Strait of Belle Isle.

Figure 3-2 shows the required cover depth above the top of the tunnel to prevent iceberg scour/pit damage as a function of the mean return period between damage events. In order to achieve a mean return period of 100 years a cover depth on the order of 3 m is required This increases to approximately 5.5 m for a 1000 year return period.

The total annual number of scour and pit events occurring over the tunnel is 3.4. If it is assumed the tunnel is shielded from iceberg keels in water depths greater than 70 m then this number drops to 2.5 events per year. As shown in Figure 3-2, this has a negligible effect on cover depths required to meet target return periods (i.e. a difference of 0.2 m for a return period of 100 years).

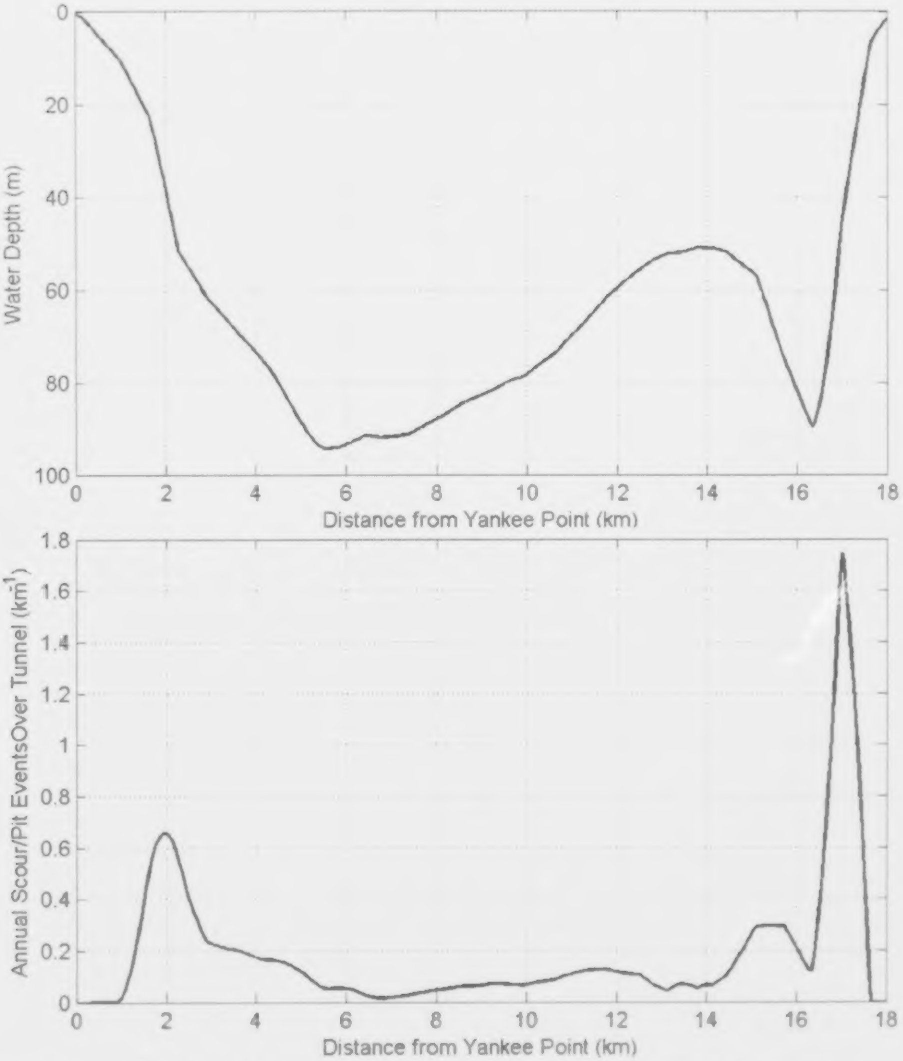

Figure 3-1 Water depth along proposed tunnel route and annual scour/pit crossings.

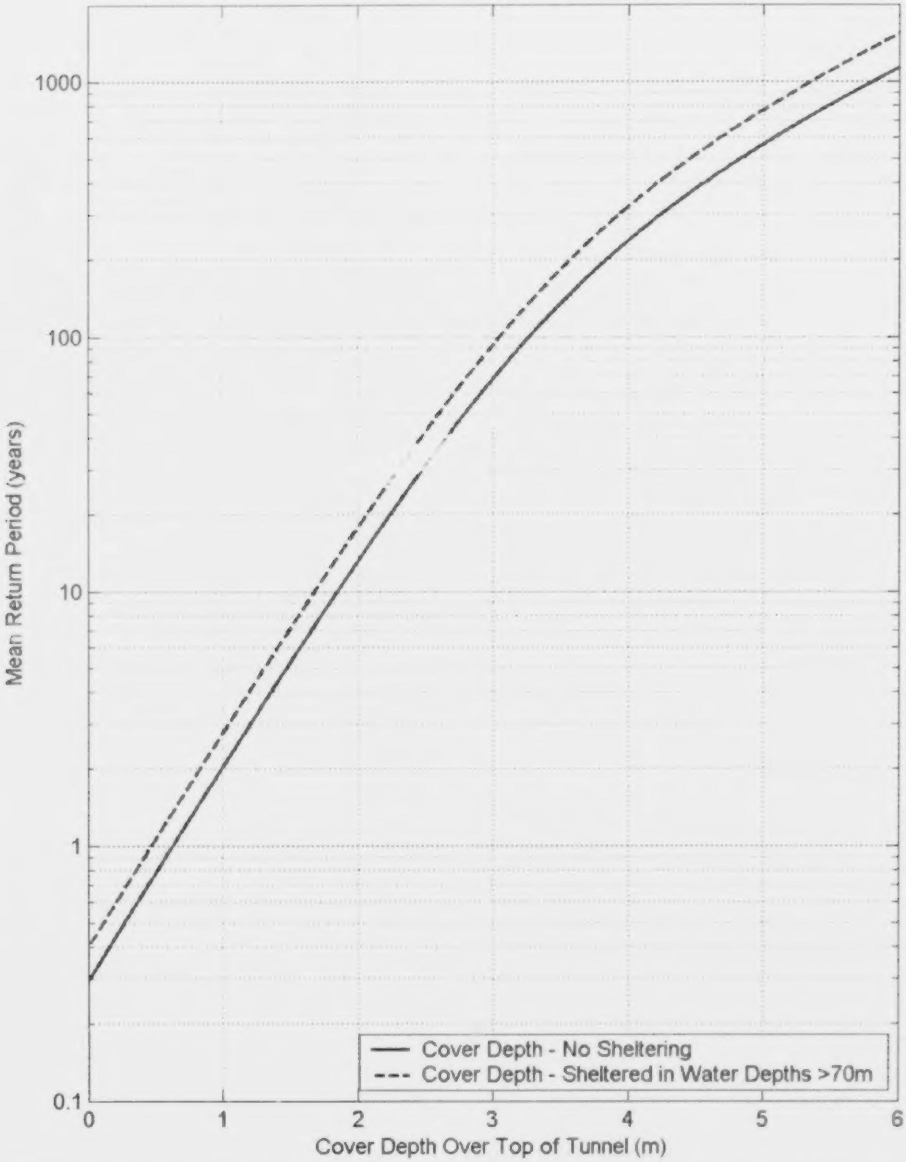

Figure 3-2 Mean return period between scour/pit events where acceptance criteria are exceeded as a function of cover over top of tunnel.

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Required cover depths over a proposed tunnel crossing in the Strait of Belle Isle running from Yankee Point to Pointe Amour are on the order of 3 to 5.5 m for return periods of 100 and 1000 years, respectively, to prevent damage from scouring and pitting icebergs. The Strait of Belle Isle is an area with high iceberg densities, shallow water depths and steep slopes, all of which contribute to increased iceberg risk. A preliminary investigation indicates that bathymetric shielding is unlikely to have a significant effect on overall cover depth requirements.

4.2 Recommendations

Scour data in the Strait of Belle Isle is extremely limited. Additional seabed surveys need to be conducted to collect site-specific data to determine the relative number of scours and pits, their shapes (lengths and widths) and depths. Iceberg drift data is also limited. A longer term monitoring program would allow drift characteristics to be more accurately determined.

The use of a drift-based grounding model (rather than the geometric model employed here) incorporating iceberg drift, iceberg deterioration, rolling, etc. would allow the effect of bathymetric shielding to be more accurately determined. There are presently insufficient data and resources to attempt this approach. (However, such bathymetric shielding is not a consideration for present purposes since a tunnel would be constrained to a straight line unlike a submarine cable.)

Required clearances between scouring/pitting iceberg keels and the top of the tunnel are based on analyses of pipeline response to scour events. These analyses should be performed specifically for a concrete tunnel once the appropriate site-specific scour parameters and the structural configuration has been defined.

It is not known whether pack ice ridge keels are a common event in the Strait of Belle Isle. However, in some areas (such as the Beaufort Sea and off Sakhalin Island) ice ridge keels are a significant factor affecting pipeline burial requirements. Iceberg ridge keels are a factor in shallower water depths (<25m). If ice ridge keels are present in the Strait of Belle Isle then these may require additional consideration, although it is likely that the cover depths maintained to protect the tunnel from iceberg risk would also suffice for ice ridge keels.

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APPENDIX C

DETAILED REPORT ON ITT OPTION

Strait of Belle Isle Crossing

Pre-feasibility Study

Immersed Tube Tunnel Option

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1. Introduction

At its narrowest point the Strait of Belle Isle (Strait) is approximately 18-kilometres wide. The construction of an immersed tube tunnel (ITT) of this length within a waterway whose depth can vary to a maximum of 110-metres, within an acceptable timeframe, represents an enormous logistical challenge.

Though many comparable studies for crossings with similar complexities been conducted in the recent past – such as a 19-km ITT alternative for the crossing of the English Channel and an 85-km crossing of the Bering Straits between Russia and Alaska, the construction of an ITT of the magnitude of the Strait of Belle Isle Crossing has never before been attempted.

Table 1 provides details of major existing and proposed ITT crossings worldwide for purposes of comparison. Currently, the worlds longest and deepest immersed tube tunnel is the Bay Area Rapid Transit (BART) Tunnel in San Francisco, CA. The BART tunnel, which opened in 1970, has a length of 5.8 km, and is located in water with a maximum depth of 40.5 metres. Though in the relatively near future tunnels will be constructed in deeper waters, these still do not approach the depths anticipated for the Strait of Belle Isle. Furthermore, the issue of crossing length and the logistical challenge of constructing an unprecedented number of tunnel elements within an acceptable timeframe remains.

Crossing	*Location*	*Function*	*Opened*	*Length (m)*	*Depth (m)*
Busan-Geoje Link	*South Korea*	*Road*	*2009 (est.)*	*3,384*	*50*
Bosphorus Crossing	*Turkey*	*Rail*	*2008 (est.)*	*1,800*	*58*
Oresund Crossing	*Denmark/Sweden*	*Road/Rail*	*1999*	*3,510*	*22*
Bay Area Rapid Transit	*USA*	*Rail*	*1970*	*5,825*	*40.5*

Table 1.1: World's Longest & Deepest ITT's

The following discussion outlines the logistical and environmental issues and constraints related to the successful construction of an ITT across the Strait of Belle Isle, and suggests how these combined constraints can be overcome, leading to the ultimate conclusion that the crossing is indeed feasible by ITT methods. The feasibility of the ITT construction is derived from the use of a combination of existing technologies, in conjunction with the assumption that some existing technologies can be further extrapolated to address the complications presented by the expected water depths.

2. Function & Geometry

Preliminary cross sections have been developed for both road and rail crossings for the Strait. The traffic envelopes including the provision for numbers of traffic lanes and tracks has been minimized to provide the most economically feasible crossing.

2.1 *Road Tunnel*

The cross-section of the road tunnel incorporates the running bore including a single traffic lane, and shoulders, ventilation ducts, and provision for egress in the event of an emergency. The width of the single traffic lane and shoulders will be sufficient to enable traffic to continue through the tunnel in the event of a breakdown. Users of the tunnel will be instructed to pull vehicles over to the side of the shoulder in the unlikely occurrence of breaking down to enable others to pass safely. The conceptual cross-section for the road tunnel is presented in drawing 213789-P005.

Horizontal Clearances

• Raised curb	– 0.75 metres
• Shoulder	– 1.25 metres
• Traffic Lane	– 3.75 metres
• Shoulder	– 1.25 metres

Vertical Clearances

Minimum clearances are measured form the top of ballast concrete.

• Surfacing depth	– 75 mm
• Traffic clearance	– 4.65 metres
• Signage/utilities envelope	– 0.5 metres

Due to the length of the tunnel, the ventilation requirements for maintaining tenable air quality and visibility during operating conditions, and for allowing safe egress from the tunnel in an incident, are onerous. The proposed ventilation system for the road tunnel comprises a hybrid longitudinal system, using jet fans in conjunction with zoned supply and exhaust ducts. The spatial requirements for the combined supply and exhaust ducts are as indicated in Figure 2.1.

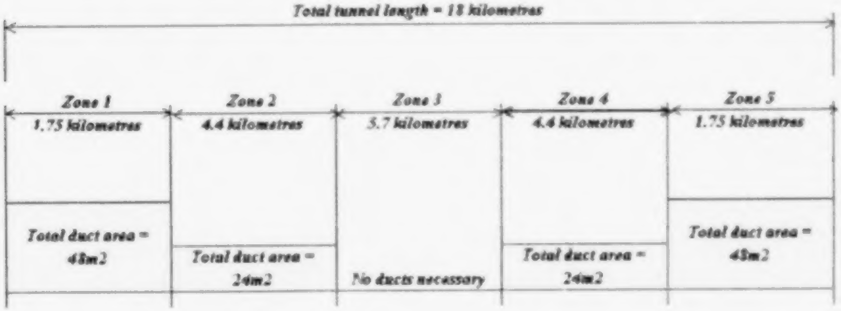

Total tunnel length = 18 kilometres
Zone 1
1.75 kilometres
Zone 2
4.4 kilometres
Zone 3
5.7 kilometres
Zone 4
4.4 kilometres
Zone 5
1.75 kilometres
Total duct area = 48m2
Total duct area = 24m2
No ducts necessary
Total duct area = 24m2
Total duct area = 48m2

Figure 2.1: Ventilation Duct Zoning

As the ventilation ducts will extend for the full internal height of the tunnel, only the tunnel width will alter between zones, then the duct widths indicated below will be necessary.

- Zone 1 – 8.0 metres
- Zone 2 – 4.1 metres

A separate 2-metre wide egress corridor is provided for emergency use. Within this corridor provision has been made for HVDC cables. The cables will be buried below the surface of the walk of the corridor, and will be encased in a low strength sand/cement mixture. The cables will be laid in a series of ess-curves to prevent damage due to differential movements at tunnel joints. Given the solid foundation material for the tunnel, such movements will in any case be minimal.

2.2 Rail Tunnel

The cross-section of the rail tunnel provides for a single-track crossing. A separate enclosure is provided for egress in the event of an emergency. The cross-section also accommodates ventilation requirements for the tunnel, which are far less onerous than for the road tunnel due to the rail system electrification. The conceptual cross-section for the rail tunnel is shown on drawing 213789-SK005.

Horizontal Clearances

- Train dynamic envelope & walkway – 4.5 metres

Vertical Clearances

Vertical clearances are measured from top of ties, which will be embedded within the track ballast.

- Rail depth – 0.185 metres
- Vehicle clearance to contact wire – 6.165 metres
- Contact wire clearance from structure – 0.65 metres

As for the road tunnel, a separate 2-metre wide egress corridor is provided for emergency use. Again within this corridor provision has been made for HVDC cables.

As the rail system will be electrified, train emissions will be minimized. It is anticipated that the ventilation of the tunnel can be accomplished using a longitudinal system comprising a series of jet fans. As indicated on the aforementioned preliminary cross-section drawing, the jet fans can be accommodated above the egress corridor. It is also anticipated that banks of jet fans can be positioned in the cut-and-cover approaches to the ITT as necessary, where changes in cross section can more readily be accommodated.

3. Tunnel Alignment

While it is prudent in terms of ventilation, operational safety, and construction cost to minimize the length of the underwater crossing, it would be similarly prudent to avoid excessively deep sections of water for construction logistics purposes.

As mentioned in the introduction, the depth of the Strait is one of the major challenges to the expedient construction of the ITT, having significant impacts upon suitable means and methods of construction including types of dredging equipment employable, and duration of placement operations for the tunnel elements.

Other factors weighing in the selection of the tunnel alignment include the necessary grades to accommodate the mode of transport within the tunnel, and additional coverage requirements to minimize the potential for damage of the in-place tunnel elements from iceberg scour.

Therefore in assessing potential horizontal and vertical alignments, consideration has been to maintaining a minimal crossing length, while seeking to avoid excessively deepwater areas. The proposed principal alignment, and an alternative alignment, for the ITT are indicated in Figure 3.1.

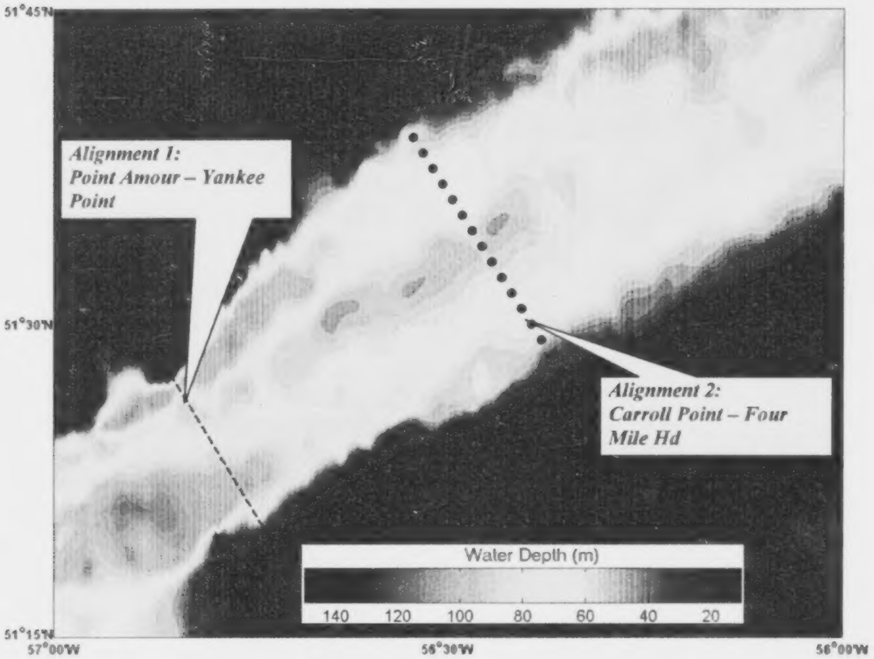

51°45'N
51°30'N
51°15'N
57°00'W
56°30'W
56°00'W
Alignment 1:
Point Amour – Yankee Point
Alignment 2:
Carroll Point – Four Mile Hd
Water Depth (m)
140
120
100
80
60
40
20

Figure 3.1: Potential ITT Alignments

Alignment 1

Alignment 1 generally follows the alignment of the previously conducted study for the HVDC Transmission Tunnel, linking Pointe Amour in Labrador and Yankee Point in Newfoundland, at the narrowest point of the Strait. This alignment yields a crossing length of approximately 18-km.

The preferred horizontal alignment for the crossing is indicated in Figure 3.2 below. The two principal goals of this alignment include:

- Locating the tunnel on a defined ridge in the Labrador Trough to minimize the depth of the crossing
- Minimizing the length of tunnel within the Labrador Trough.

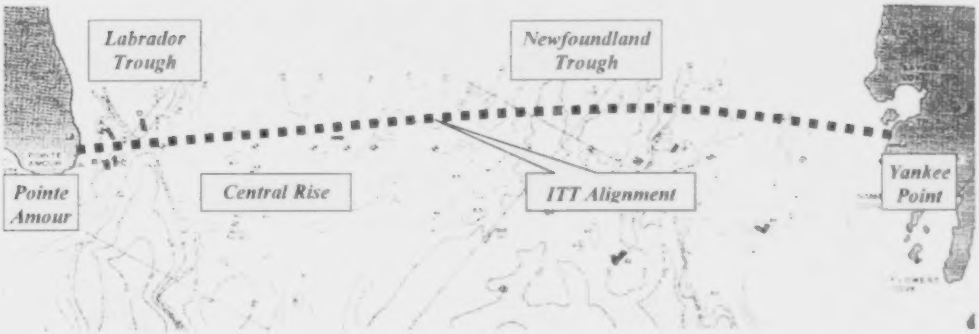


Figure 3.2: Alignment 1

The vertical profile of the tunnel will typically follow the profile of the bed of the Strait. The burial depth for the ITT elements will be based upon requirements for mitigating the risk of the tunnel being impacted by scouring and/or grounding of passing icebergs.

As identified within the C-Core Study on iceberg scour risk within the Strait (Ref. 3), the depth of cover required over the tunnel varies depending upon the mean return period selected. Based upon the length of the crossing, it can be readily understood that designing the tunnel for a return period of 200 years (3.8m cover) as opposed to 100 years (3.25m cover) represents a significant difference in construction cost.

It is anticipated that the tunnel structure will have a design life of at least 100, and possibly 120 years. As, based on experiences elsewhere, it is likely that the tunnel will remain in service beyond this design life, a 150-year return period, corresponding to a depth of cover of 3.5m typically, and 3.25m in depths of water greater than 70m has been assumed for this study quantification and cost estimating purposes.

It is possible that, with greater study, and based upon probabilistic risk, that in certain locations these figures could be reduced. For instance, in relatively shallow waters of 25 metres or less, the tunnel structure itself could be designed to accommodate impacts and grounding loads imposed by bergy bits and growlers.

The principal issue with the Pointe Amour – Yankee Point alignment is the water depth, and the effects of the water depth on dredging/excavation methods for the trench for the immersed tube tunnel.

As mentioned within the introduction, the deepest ITT, either in planning or construction is sited at a maximum of 56 metres deep. Based upon the bathymetry contours, approximately 65-70 percent of the crossing length will be at a depth greater than 60 metres. This presents an enormous challenge for the construction of the trench, requiring significant advances in currently available technologies.

Alignment 2

Alignment 2 seeks to address the water depth related issues of the first alignment. Situated further west of the Pointe Amour – Yankee Point crossing site, the alignment approximately links Carroll Point in Labrador with Four Mile Head in Newfoundland.

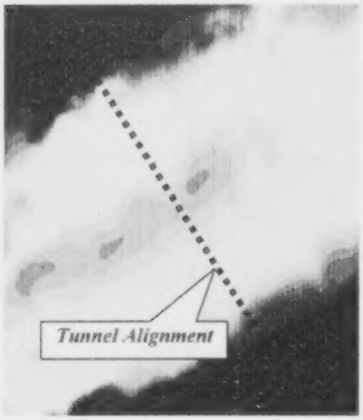


Figure 3.3: Carroll Point – Four Mile Head Alignment

The depth of the crossing is much reduced at the indicted location, with a maximum anticipated depth of approximately 65 metres, which is much more feasible in terms of dredging technologies.

However, the crossing is approximately fifty percent longer than the Pointe Amour –Yankee Point alignment, measuring approximately 27-km, which raises equally significant issues on tunnel cost and construction schedule.

In terms of the study of the feasibility of the crossing, Alignment 2 will only be considered further if it is demonstrated conclusively that the construction of the tunnel on Alignment 1 is not feasible.

4. Surficial and Bedrock Geology

A general understanding of the geology, and in particular the surficial geology, of the Strait is fundamental to the immersed tube tunnel concept. This brief description addresses both the bedrock and surficial geology of the area, and is based largely upon the boring program conducted in 1981. This program was the only offshore program to retrieve core, and drilled 22 shallow borings from a pressurized diving bell. Of these 22 borings approximately 12 are on the proposed alignment.

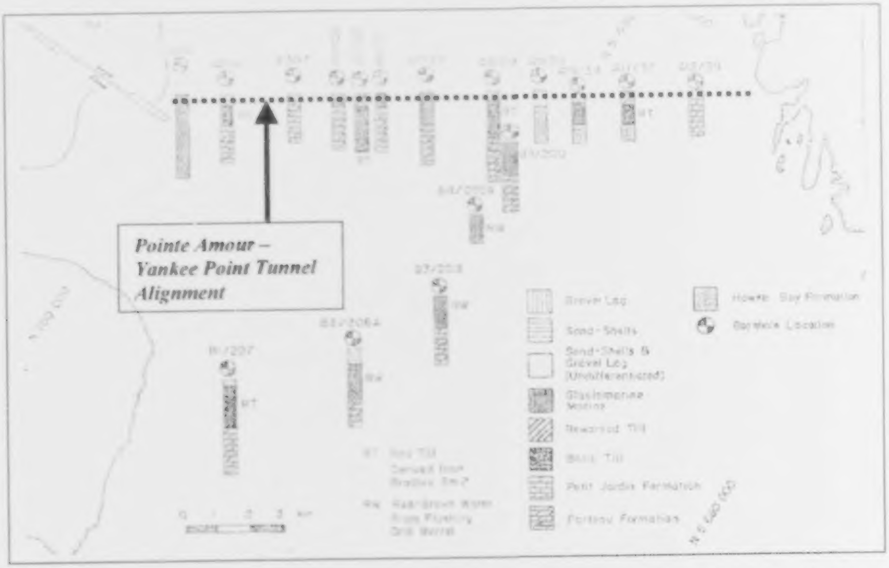

Pointe Amour – Yankee Point Tunnel Alignment
Gravel Log
Sand-Shells
Sand-Shells & Gravel Log (Undifferentiated)
Glaciomarine Marine
Reworked Till
Basal Till
Petit Jardin Formation
Forteau Formation
Hawke Bay Formation
Borehole Location
RT Red Till Derived from Bradore Fm.?
RW Red-brown Water from Flushing Drill Barrel
0 1 2 3 km

Figure 4.1: 1981 Offshore Boring Program

The borings indicate that the overburden consists of thin deposits of shells, sand, gravel, glaciomarine marine deposits and dense till. Along the route from Point Amour to Yankee Point, the average overburden thickness, including the till, is approximately 2.5 to 3 m. Two of the borings, A1 and B4, did not however reach the bedrock and encountered either the Glaciomarine marine deposits or tills to full depth. The maximum thickness of these surficial deposits is not known and estimates vary depending upon the source. It does however seem likely that depths will exceed 5m, and perhaps reach 10-12 meters in localized depressions. The maximum drilled depth of bedrock in this investigation was 3.69m with an average depth of 2.5m. The bedrock consisted primarily of limestone and shale, with some sandstone, and is generally described as dense and fresh.

The borings revealed that on the Labrador side of the Strait, the bedrock consists of the Forteau Formation, which is a red to gray limestone and gray shale. In the area of the Newfoundland Trough, the Hawke Bay formation is encountered, which is composed of interbedded microcrystalline limestone, black shale and orthoquartzites. Along the Newfoundland coast the Petit Jardin Formation is found and is generally described as a gray and brown dolostone.

In addition to the seabed borings a number of seismic studies have been conducted in the area with varying degrees of success. What is clear is that there are faults in the area and that rock ledges may exist.

Although it is reasonable to assume that the available geotechnical information is adequate for this phase of the study, future planning and design will require a substantial increase in the amount of available geotechnical data. At present there is on average more than 1.5 km between seabed borings. The variation in terms of strata and profile between borings can therefore be considerable, which makes accurate determinations of the quantities difficult. Further laboratory testing may also be appropriate.

Material Properties and Trench Stability

Geotechnical analyses were performed on the soil retrieved during the 1981 offshore program and a summary table of the thickness, grain size, and geotechnical properties of the surficial map units is included in the 1992 report on Surficial and Bedrock Geology by Woodworth–Lynas et al (Ref. 4). A selection of relevant properties has been reproduced in Table 4.1.

Description	*Strength*	*N Value*	*Preconsolidation Strength (kPa)*
Sand - Shells	Very Loose to loose	0-15	Not applicable
Glaciomarine - Marine	Very soft to loose	2-4	2.6
Glacial Drift	Medium Dense	9-46	
Lodgement Till	Very Dense	29-35	394-1089

Table 4.1: Geotechnical Properties (reproduced from Woodworth-Lynase et al)

The stability of the trench side slopes in the overburden is principally governed by the material properties and the angle of the slope. Other parameters including the thickness of each layer and slope history having a secondary effect. In order to estimate stable slope angles a number of assumptions have had to be made. These would need to be verified by testing and additional investigation at a later stage. As the layer thickness is unknown, the stable slope angle estimates in the table below are based primarily on experience and assessment of the material properties.

Overburden unit	*Estimated Slope angle for a stable slope based on an submerged infinite slope analysis*
Sand – Shells & Gravel Lag	1 vertical to 2 horizontal
Glacio Marine – Marine	1 vertical to 4 horizontal
Glacial Till	1 vertical to 3 horizontal

Table 4.2: Estimated Stable Slope Angles for the Soil Strata

Rock slopes generally fail along existing geological weaknesses and it is only with very weak rocks or very high cuts that the intact strength of the material becomes significant. It is therefore likely that the side slopes of the trenches are governed by the geometrical relationships between discontinuity planes. Currently little information exists regarding the state of the bedrock near the seabed surface, so it has also been assumed that there is negligible weathering. If future investigation shows that significant weathering has occurred the side slopes may need to be assessed as per a soil.

The geological information that has been reviewed to date suggests that the sedimentary rock strata are nearly flat lying or gently dipping. We have therefore assumed that the slopes will need to be cut so that they will be sufficiently off vertical to prevent loose blocks toppling down. This assumption about the failure mechanism would need to be verified at a latter date, and in particular the influence of vertical fracture spacing examined. The information available to date also suggests that there is no significant difference between the different geological units, and the same slope angles for each have therefore been adopted. This is an area worthy of further study and economies may be possible once more detailed information about each unit is available for analysis.

Bedrock Formation	*Estimated Slope angle for a stable slope*
Forteau Formation – limestone and shale	5 vertical to 1 horizontal
Hawke Bay Formation – white Orthoquartzite	5 vertical to 1 horizontal
Petit Jardin Formation – Grey & Brown dolostone	5 vertical to 1 horizontal

Table 4.3: Estimated Stable Slope Angles for the Bedrock

5. Fabrication Sites

Significant research was undertaken by Husky Energy as part of the White Rose Development project, to identify and characterize offshore fabrication facilities in Eastern Canada. The results of the investigations were published in the White Rose Development Application Volume 1 report, dated January 2001.

The general fabrication requirements defined for the White Rose facility have many similarities to those of the ITT including large drydock facilities, craneage, concrete batching plant, reinforcement bending shops, and deepwater storage areas.

In particular two of the sites identified within the Husky report appear to offer ideal conditions for the fabrication of the tunnel elements. These sites are:

- Cows Head Fabrication and Marystown Shipyard site
- Bull Arm Site

The location of both sites in relation to the project area is indicated in Figure 5.1 below. Approximate towing distances for tunnel elements are also indicated.

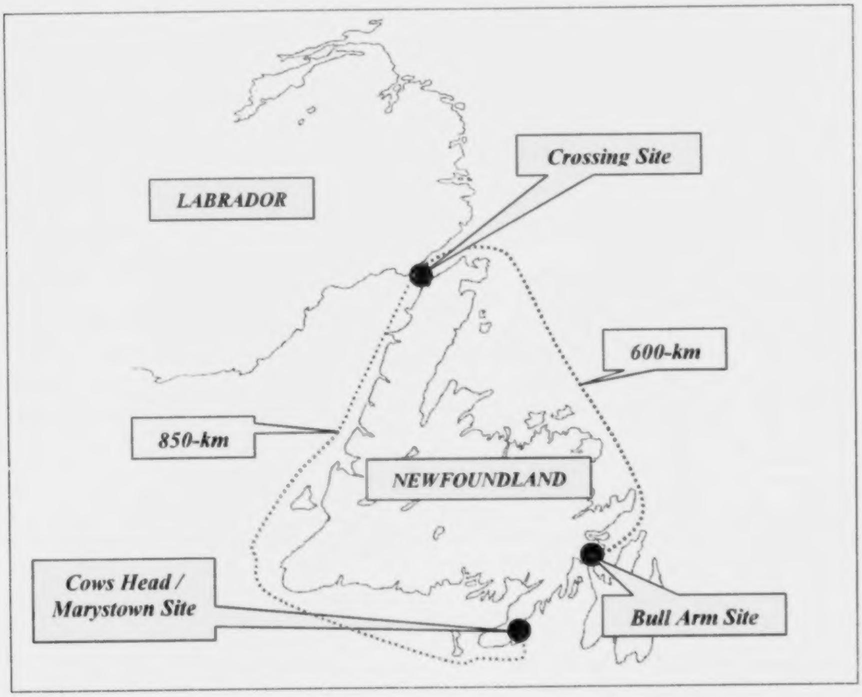


Figure 5.1: Potential Tunnel Element Fabrication Sites

Using an average tow speed of 2 metres per second for a fully weighted unit, and with calm conditions, the journey from the fabrication sites to the tunnel location will be in the order of 4-5 days.

Though potential fabrication sites can be identified as part of any study, ultimately the choice of where the elements are built rests with the successful contractor, who will have priced the lease requirements for a particular fabrication site into his bid. Also, though the identified sites seemingly offer ideal fabrication conditions, circumstances may dictate that they cannot be used for tunnel element fabrication. For instance:

- Depending upon the project schedule, the sites may not be available at the required times
- Given the multi-year construction duration, the fabrication of the tunnel elements for a one-off project may result in the facilities having to turn away long-standing customers, which they may be reluctant to do.
- The successful contractor may determine that the towing distances for the tunnel elements present an unacceptable risk to the project schedule, and may decide instead to construct an ad-hoc facility close to the tunnel location.

The crossing is certainly long enough to warrant the construction of a purpose built casting facility, suited to the project needs and schedule constraints. A similar facility, constructed for the Oresund Tunnel, which forms part of a fixed link between Denmark and Sweden, is indicated in Figure 5.2.

Conversely, in order to generate sufficient element production to meet an agreeable construction duration, the use of multiple fabrication locations may be a necessity.

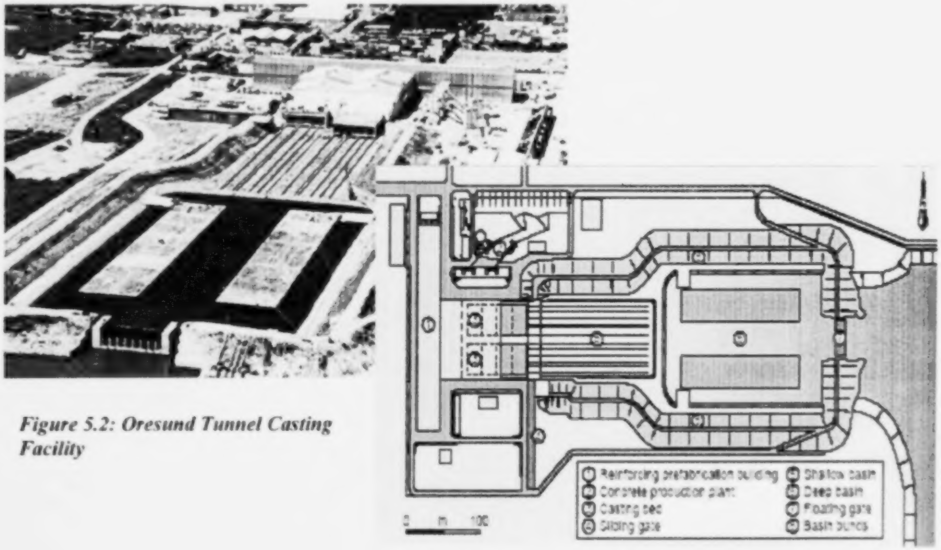


Figure 5.2: Oresund Tunnel Casting Facility

6. Tunnel Construction Methods

6.1 Historical Trends

Since the construction of the very first transportation ITT in 1910 - the Detroit River Tunnel, linking Windsor, Canada with Detroit in the US - two very different, largely geographically based methodologies for the design and construction of subsequent tunnels have developed.

In the US, the use of steel tunnel sections has been prevalent, whereas in Europe and the Far East reinforced concrete tunnel sections are almost exclusively used, and an attitude of 'never the twain shall meet' has existed between the proponents of each technology. The reasons for the development of the separate technologies has not been documented, but can be speculated. After the construction of the Detroit River Tunnel, the US continued to build a number of ITT's in the early 1900's. These were mainly steel tunnels, which could be attributed to the strength of the US steel market and the availability of suitably skilled resources. The first European ITT however, the Maas Tunnel in the Netherlands, was not built until 1941. It can be imagined that in 1941 all steel in Europe was assigned for other purposes, setting a resulting precedent for the use of concrete technology.

Both construction methods have general rule-of-thumb advantages and disadvantages, which are presented in Table 6.1, below.

Reinforced Concrete Sections	*Steel Sections*
Advantages	***Advantages***
Conventional construction methods using readily available materials.	*No elaborate casting facility is necessary.*
Construction carried out in ideal conditions enabling a high degree of quality control.	*Initial steel fabrication accomplished quickly.*
Rectangular tunnel cross-section is tailored to suit the traffic envelope, providing efficiency in design and construction.	*The inner steel shell acts as an impermeable membrane.*
	The circular shape of the structural shell components is efficient for carrying loads in ring compression.
Disadvantages	***Disadvantages***
A purpose built casting facility is typically required.	*Requirements for minimum negative buoyancy results in much of the steel being an additional cost.*
Concrete is brittle by nature with a tendency to crack due to flexure and thermal strain. Incidence of cracking must be carefully controlled to ensure the structure remains durable.	*Much of the keel concrete is placed when the element is afloat, under difficult conditions, resulting in poorer workmanship.*
	The circular shape generally does not fit well with rectangular traffic profiles, resulting in additional void space which translates to cost.
	Tunnel element length is limited by flexure induced by concrete placement while afloat.

Table 6.1: General Comparison of Concrete & Steel ITT's

Other than the Detroit River Tunnel there are two other ITT's in Canada, the George Massey Tunnel, in Vancouver, and the Lafontaine Tunnel in Montreal. Both tunnels utilized concrete element construction. It can again be speculated that the presence of European based design and construction firms on both projects resulted in the selection of concrete technology.

In recent years there have been exceptions to these general rules. Since the construction of the Detroit River Tunnel, twenty-five immersed tube tunnels have been constructed in the US, and twenty-one of these are steel. However, the two most recent US ITT projects have involved concrete element construction for crossings of the Fort Point Channel in Boston. Also, recent studies for potential ITT's in New York and Virginia have also indicated that concrete construction would be the preferred approach.

Conversely, in Japan, relatively recent ITT's have been constructed with external steel membranes, serving a dual purpose as both structural member and waterproofing.

Significant research has since been undertaken in the UK and Japan regarding the viability of a true composite, or steel-concrete-steel (SCS) sandwich ITT option. In the UK, the Steel Construction Institute, in association with Cardiff University in Wales, has produced a number of publications demonstrating that composite construction is appropriate for consideration with ITT projects.

The findings of the British studies have been borne out in Japan, with the construction of the Kobe Kou Minatojima Tunnel, which was completed and opened in 1997. The ITT, linking Kobe with Kobe Port Island, is recognized as being the first in the world to employ full sandwich construction. Based upon the success of this project it appears likely that further ITT's in Japan will also be constructed using SCS methods.

The preceding paragraphs intend to suggest that though historically, location has largely determined the preferred choice of tunnel construction method, more recently more logical choices have been made, based upon reasoned comparison of all feasible construction methods.

6.2 ITT Construction Alternatives

An understanding of the construction process for the ITT is required to enable the reader to appreciate more fully the issues related to the construction of the structure. A description of a ***typical*** process for each of the potential construction methods for the tunnel sections follows.

Reinforced Concrete Tunnel Construction

Reinforced concrete tunnel elements are normally constructed in a purpose built casting facility, constructed on a parcel of land with access to a waterway with sufficient draft to accommodate the tunnel elements. The fabrication site can be adjacent to or remote from the tunnel site with the choice of the actual site being left to the Contractor.

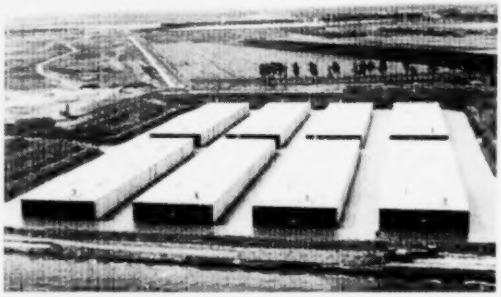


Figure 6.1: ITT Elements in Casting Basin, Liefkenshoekt Tunnel, Belgium

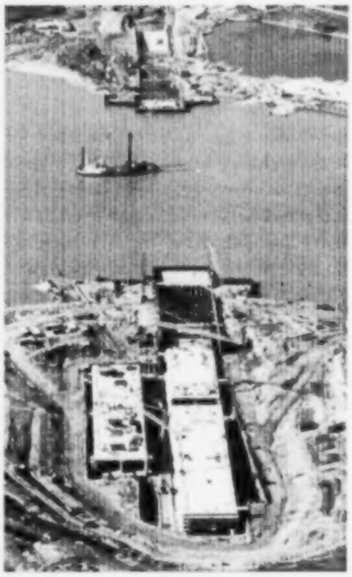


Figure 6.2: Tunnel Construction & Channel Dredging, Medway Tunnel, UK

The reinforced concrete ITT elements are typically cast in a number of segments, each in the region of 20-metres in length, to form a unit in the region of 120-metres long, though much larger sections can be achieved where hydrodynamic conditions permit. Segments are normally cast in a predetermined sequence to minimize the effects of shrinkage and thermal cracking. Element construction begins with base slab pours followed by construction of the tunnel internal walls. Finally the external walls and roof slab for each segment are poured together in a single pour, again in an effort to reduce the incidence of shrinkage and thermal cracking.

Steel frames are cast into either end of the tunnel unit. These frames are installed to close tolerances, and are used to locate the tunnel immersion joint seals, the Gina and Omega gaskets. Normally an additional construction joint is provided close to the ends of the elements to facilitate positioning of the end frames.

On completion of the tunnel concrete, the elements will be outfitted for flotation. Large ballast tanks will be constructed within the elements, typically of steel/timber construction with a membrane liner. The ends of the elements will be sealed with steel or concrete bulkheads. The primary immersion joint seal, the Gina gasket, will be fitted to the leading end of the unit and waterproofing will be applied as necessary.

When ready, the dock or casting basin will be flooded. At this time the tunnel ballast tanks shall be full of water to prevent the tunnel elements from rising to the surface and damaging each other. While held on the basin floor the tunnel elements will be inspected. Any noticeable leaks or damp patches will be repaired by the Contractor prior to transport.

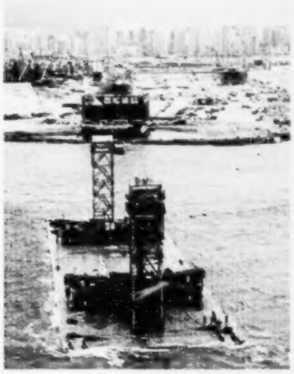


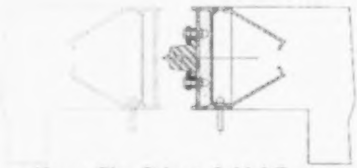
Figure 6.3: Element prior to Immersion, Western Harbor Crossing, Hong Kong

The tunnel elements will be brought to the surface in a controlled manner by removing water ballast. The amount of water in each ballast tank will be trimmed to ensure the tunnel floats with a desired, constant freeboard of around 300 mm, though this dimension will ultimately be selected to suit the length of tow and significant wave heights.

The elements will be towed from the basin and transported to an outfitting area adjacent to the tunnel site where pontoons, access shafts, bollards and miscellaneous other fittings required for the immersion process will be positioned on the tunnel roof. Once outfitted, the tunnel elements will be towed to their final location, which will be accurately assessed by surveys from several locations, and lowered from the pontoons into the pre-dredged trench by opening valves in the end bulkheads and allowing the ballast tanks to fill with water.

Pin jacks will be lowered from the bottom of the unit to provide temporary support in the trench before a pumped sand foundation is placed to fill the void between the bottom of the trench and the base of the unit. The sand can be pumped from a barge through a series of pipes cast into the walls of the tunnel to provide a series of overlapping sand 'pancakes' which provide a continuous foundation.

Remaining elements will be sequentially brought from the casting basin, outfitted, and lowered into position. Close tolerances can be achieved on unit position through survey and couplings between alignment brackets on adjacent elements.



Above: Gina Prior to Initial Contact
Below: After Omega Installation

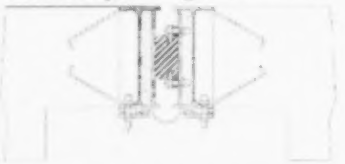


Figure 6.4: Tunnel Immersion Joint

As mentioned, tunnel joints comprise a pair of rubber gaskets, the Gina and Omega seals. The Gina seal is attached to the tunnel unit prior to immersion. As the unit being lowered approaches a previously placed unit, alignment brackets ensure the elements contact at the correct location. The two elements are pulled together, compressing the soft nose of the Gina gasket to form an initial water seal. The space between the bulkheads of the two elements is then dewatered via valves in one of the bulkheads. This creates an air gap causing an out of balance hydrostatic force at the opposite end of the placed unit which causes significant compression of the Gina seal thus creating a watertight joint. The remaining tunnel elements are jointed in a similar fashion.

Backfilling of the dredged trench proceeds sequentially with the tunnel unit placement. The sides of the tunnel are backfilled with granular material and regular fill to the top of the tunnel. A rock protection layer is placed over the tunnel elements to protect the structure from impacts from grounding vessels and dragging or dropping anchors. During backfilling some settlement of the tunnel elements may be expected, but such settlements will be minimal, and can be estimated and accommodated within the design process. During backfilling, water ballast within the tunnel elements is replaced by permanent concrete ballast in the form of roadway or track slab, and refuge walkway. The ballast transfer process must be carefully staged to maintain minimum factors of safety against flotation at all times.

Figure 6.5: Completed ITT, River Lee Tunnel, Ireland

Typically an underwater closure joint is required to complete the tunnel. The final tunnel unit to be placed will be constructed approximately 1.5-2 metres shorter than the other tunnel elements, ensuring that the unit can be deposited in the dredged trench without difficulty. Divers will then place struts in the gap between the two elements around the perimeter of the tunnel, and place gasketed steel dam plates around the external perimeter of the tunnel, closing off the gap. The water inside the gap can be pumped out into a ballast tank. Reinforcement can be connected to couplers left in the face of the tunnel elements, and the joint concreted in stages, to allow the struts to be removed.

After initial elastic settlements are complete, the secondary expansion joint seal, the Omega, is fitted. The seal is clamped across the expansion joint and tested to a significantly higher pressure than required by design.

Once the primary structural elements are complete, the various M&E components, finishes, etc. can be installed.

Steel Shell Tunnel Construction

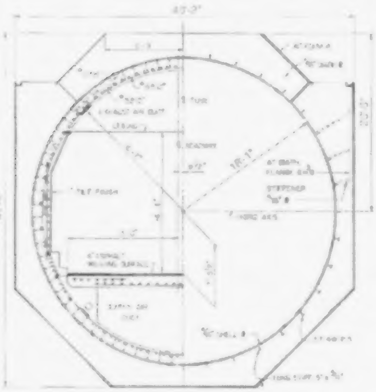


Figure6.6: Steel Shell Tunnel Cross-Section

The steel shell tunnel would likely be similar to that indicated in Figure 6.6, which was used for the Second Hampton Roads Tunnel in Virginia. Variations on the pictured cross-section, such as with a flat invert to give a horseshoe shaped section, would also be fully investigated in future stages of the project.

Fabrication of steel elements customarily takes place within an existing shipyard, dry dock facility, or a steel fabrication plant with slipway access to a waterway. If necessary, elements can also be constructed in purpose built areas adjacent to the tunnel site with waterway access, if land is available.

Once a site is identified and construction is underway, the structural steel shell plate, form plate, intermediate diaphragms and stiffeners are fabricated in convenient subassemblies and fitted together on slipways to exacting tolerances. Reinforcement for the shell plate liner concrete is normally fixed at this time. Steel bulkheads are then fitted at both ends of the elements.

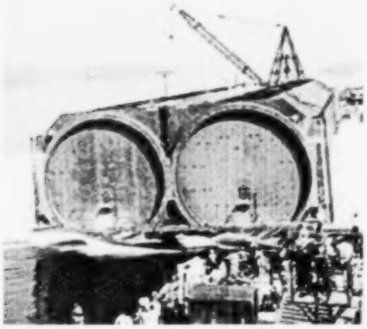


Figure 6.7: Launching Steel Element, Fort McHenry Tunnel, Baltimore, MD

Prior to launching, the shell plate and bulkhead welds are tested for watertightness by coating the outside of the plate with a soap solution and jetting compressed air against the inside of the shell. Any required weld repairs are made as necessary. External keel concrete is placed to give the tunnel unit additional stability when afloat.

The tunnel elements can be launched sideways or endways into the waterway. The elements are more suited for a sideways launch during which they are supported by launching sleds on a series of parallel ways located under intermediate diaphragm positions. The elements are held in place until launching by a number of triggers, which are released simultaneously. Jacks can also be provided to start the tube, if necessary. Chains or similar restraining methods control the launch speed of the tunnel unit and control the distance the tube runs into the waterway. End launching of the tunnel elements is carried out in a similar manner, but again can induce significant bending of the tunnel section when the unit is part in the water and part on the slipway.

Once afloat the elements are transported to an outfitting pier adjacent the tunnel site in preparation for placement in a pre-dredged trench. The remaining concrete for the steel shell plate liner, external cap concrete and ballast between form and shell plates is placed in a carefully staged sequence to control longitudinal bending and floating stability of the tunnel unit. Pontoons, access shafts, bollards and miscellaneous other fittings will also be positioned on the tunnel roof. Dredging and tunnel foundation placement will proceed concurrently with the fitting out of the elements.

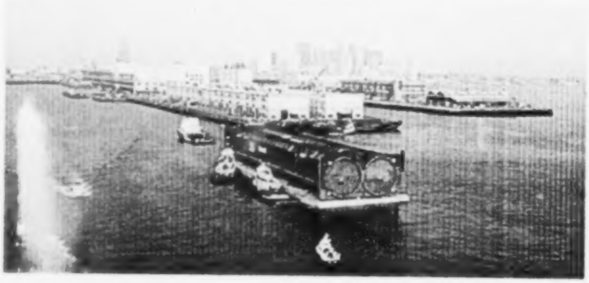


Figure 6.8: Transport of Steel Element, Ted Williams Tunnel, Boston, MA

After fitting out, the tunnel unit will be negatively buoyant and will be supported by the pontoons. The tunnel elements will then be towed the short distance to the dredged trench and lowered to their final position on a pre-placed, screeded gravel foundation. The foundation is placed to close tolerances, typically in the region of ± 25 millimetres. The steel shell is sufficiently ductile to allow the elements to overcome any local variations in the gravel placement. Remaining elements will be sequentially brought from the fabrication yard to the outfitting pier and lowered into position. Alignment brackets on the ends of adjacent elements allow sequential placement to strict tolerances.

The tunnel elements can either be jointed using a gasketed connection similar to that described for the concrete option, or by forming a rigid tremie concrete joint between steel plates connected to the ends of interfacing elements. A closure joint will be formed, in a manner similar to that described for the concrete option.

Backfilling and placement of the rock fill protection layer shall proceed sequentially with tunnel unit placement, also as previously described for the concrete option.

Finally, internal work can be completed comprising liner concrete, roadway or track slab and refuge walkways, and installation of M&E systems and finishes.

Composite (SCS) Tunnel Construction

The SCS tunnel elements can be fabricated in a manner similar to that described for either the reinforced concrete or steel shell tunnels depending upon the availability and suitability of any existing casting facilities. The SCS tunnel appears to offer principal advantages of both the concrete and steel alternatives. The tunnel cross section can assume the rectangular profile offered by the concrete option and can thus be tailored to suit a specific traffic envelope, and the external plate offers the watertightness of the steel option. The tunnel elements comprise of internal and

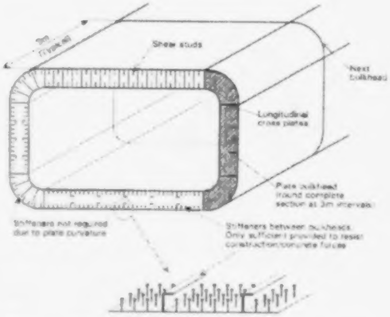

3m (typical)
Shear studs
Next bulkhead
Longitudinal cross plates
Plate bulkhead (round complete section at 3m intervals)
Stiffeners not required due to plate curvature
Stiffeners between bulkheads. Only sufficient provided to resist construction/concrete forces

Figure 6.9: Composite Tunnel Components

external steel plates, sandwiched by a layer of highly fluid concrete, which is required to ensure all potential voids between plates at stiffener locations etc. are completely filled. The internal and external plates are welded together to form continuous shells, supported at regular intervals by internal diaphragms and stiffeners.

The construction process for the tunnels can be as described for either the reinforced concrete or steel shell tunnels.

6.3 Dredged Trench Construction

Section 4 of this report describes the expected surficial and bedrock geology in some detail. However, in terms of the methods necessary to construct the trench only two classifications of material exist, namely overburden and bedrock.

At this stage it is believed that all overburden materials could be removed using either clamshell or hydraulic equipment without the need for pretreatment. However, the upper limit for a cutter suction dredger at depth is approximately 5,000 psi, which is well below the current strength estimates for the bedrock. Consequently blasting or some other method will be necessary to break up the limestone and sandstone layers along the majority of the route. The possible exceptions being small areas in the vicinity of the faults which may be breciated and fractured. Once the bedrock has been broken up, the trench profile can be cleared using a clamshell grab or possibly a suction dredger depending upon typical blast rock size.

A description of current technologies for dredging, underwater blasting, and submersible equipment is provided. It is foreseeable that a combination of all the technologies presented will be required for the excavation of the trench.

Current Dredging Technologies

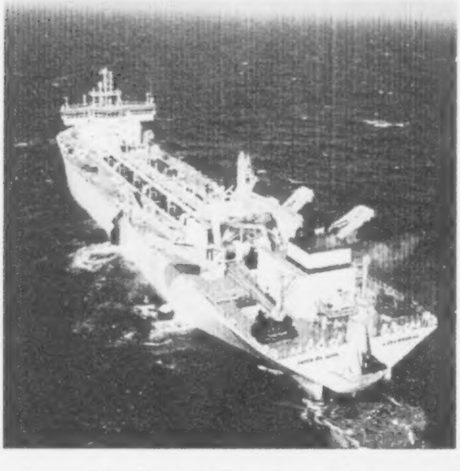


Figure 6.10: Vasco da Gama in operation

Until very recently little or no suction dredging was done in water greater than 50 metres deep. Below this depth the suction tube becomes too long for the pumps inside the hull of the dredger to maintain a proper vacuum. However, in the last few years dredging operators have been developing equipment and in particular submerged booster pumps, to enable them to dredge at much greater depths, primarily to obtain sand in areas where no viable shallow deposits exist. The result of this technological advance is that large, modern hopper dredgers such as Vasco da Gama owned by Jan de Nul have dredged in water depths of around 135 metres, with capacity to go to 160 metres. There are very few vessels capable of suction dredging at these depths, although more are likely to exist in the future. As the water depth decreases more and more vessels are able to operate and there are, in comparison, many that are capable of suction dredging at depths of up to 80 metres.

Normal clamshell grabs are typically limited to around 40 metre depths, with some of the larger equipment can reach 50 metres. As an alternative, at least two remotely operated vessel (ROV) steered clamshell grabs (10 and 16 m^3 respectively) has been developed in the last few years which can operate at water depths of up to 1,000 metres, with tolerances of only a few centimeters. These ROV's were used successfully in 2003 in water depths of around 125 metres from the Seahorse, owned by Boskalis, which in conjunction with Vasco da Gama created three 9m deep glory holes for the White Rose Project and Husky Energy, 350 km East of Newfoundland.

It is anticipated that either hydraulic or clamshell dredging, or a combination of both will be employed in 'shallower waters in depths up to 50 metres. In the deep water sections, large dredge equipment such as Vasco de Gama or similar will be required.

Current Blasting Technologies

Seabed blasting is normally carried out from jack-up barges. The legs or spuds of the barge rest on the seabed, providing stability and greatly simplifying the drilling, charging and firing of the holes. With current limitations on below water spud length of between 40 and 50 metres, this construction method may be practical for part of the crossing length, but is not possible within the deeper reaches of the Labrador and Newfoundland Troughs.

Based upon current technology, the drilling for the deeper areas will have to be conducted from floating vessels, which would be either anchored, or constantly manoeuvring to maintain position. By using offshore industry techniques and equipment, the necessary holes could be drilled, charged, and fired from the surface. However, this operation is likely to be slow and difficult. Although blasting in 100 metres or more of water is achievable, it is not common, and some of the technology is not well proven. Some development work is likely to be needed in terms of techniques and equipment. For example, it may be possible to use a ROV for some of the latter stages to improve production rates.

Again, in the defined 'shallower ' water, trench excavation will completed by either hydraulic methods or through the use of clamshell in conjunction with underwater blasting. For the latter scenario, jack-up barges would be used to facilitate the blasting process. For deeper waters the use of floating vessels will be necessary for blasting purposes.

Current Submersible Equipment Technologies

An alternative to blasting is the use of seabed-based equipment. In the last 10 years a number of tracked, land-based construction machines have been modified and developed to operate at depths of up 1,000 metres. The equipment can be fitted with a variety of tools including hydraulic crushers and breakers, rotating excavating tools, or standard buckets. Given the scale of this project, widespread use of this technology is probably uneconomic, though it may prove useful for localized excavation and trimming.

Submersible cutters have been developed for specific projects such as the Cross Channel Interlink and one could be developed for this project. The principle involves the creation of an ROV with some kind of rotating cutter. The ROV is then "driven" along the alignment, excavating the trench. The equipment is expensive to develop, but given the length of the crossing, it may prove economical.

The use of submersible equipment has not been considered in the development of the preliminary construction and cost estimates, though the technology will warrant further investigation as the project develops.

Dredge Production & Duration

The presence of winter sea ice will have a significant effect on the dredging operation. It is currently predicted that dredging will not be possible between January and May, which means that the effective work year will consist of approximately 7 months or 213 days. Therefore, the dredging schedule will have to extend over a number of years.

Although trailing suction dredging is likely to be capable of higher production rates in ideal circumstances, clamshell grabs are considered to be more versatile and are capable of dealing with a wider range of materials and conditions. In order to estimate the expected dredge duration it has been assumed that drag and drop dredging will be used. In this method, material is picked up, moved sideways underwater and dropped adjacent to the trench using a clamshell. Based on the available duration and typical deepwater cycle times it has been estimated that the dredging will take 7 vessel years for the rail tunnel and 9 vessel years for the road tunnel. It has been assumed that any necessary preparatory work such as blasting is carried out in parallel to the dredging and has little effect upon the overall durations.

Due to the length of the crossing, it is reasonable to assume that multiple dredges can be operating simultaneously without impacting each other. However, initial enquiries have suggested that there are currently no vessels on the Eastern Seaboard with sufficient depth range to dredge the deeper sections of the alignment although there are suitable vessels for the shallower sections. Specialist deep dredging vessels, such as the Vasco de Gama, will need to be mobilized from around the world. Although this does not present any insurmountable difficulties, as all the appropriate vessels are capable of open ocean journeys, we understand certain safety inspections will need to be carried out, before operations can start in Canadian Waters. Some risk will also exist as to the availability of the dredger at the required times, as vessels may be gainfully employed elsewhere. Importing such vessels will also induce large mobilization fees.

Observations within the Strait (Ref. 4) suggests that bottom currents frequently move sediment. Visual examination from a submersible along a test plough route approximately 1 year after plowing showed that at a depth of 90 metres, the trench had filled with shell hash, consisting of loosely packed fragments 1 to 2 cm in diameter. This suggests that during the interval between dredging and placing of the ITT elements, and certainly in the winter period where marine operations are suspended, any open excavation will have a tendency to accumulate shell hash or other sediments. Redredging of the trench will therefore be required prior to placing the elements. At this stage it is difficult to estimate the quantities of redredging that may be required and this should be the subject of a future study. For cost estimating purposes an allowance equivalent to 15 % of the original total excavation has been assumed. Removal of the material by hydraulic methods can be accomplished rapidly.

The scale and nature of this project are unique, and will necessitate the use of cutting edge techniques, perhaps developed specifically for this project and its environmental conditions.

Consequently, estimating the cost of constructing the trench is difficult and a significant contingency sum is included. Details of the cost estimate are included in Appendix A.

6.4 Site Constraints

For the Strait of Belle Isle Crossing, many of the general advantages and disadvantages of each ITT construction technology apply. These must be considered in conjunction with the many critical, site-specific issues which exist for the tunnel, in making an impartial assessment of the preferred tunnel construction methods.

Significant factors in determining the feasibility and preferred construction methods for the ITT include:

- Crossing length
- Water depth
- Geology
- Hydrodynamic conditions
- Meteorological factors
- Environmental factors

The implications of each of these issues for the construction of the ITT follow.

Crossing Length

The primary implication of the length of the crossing, at approximately 18-km is upon construction schedule. A method of fabrication which allow rapid production and placement of the tunnel elements is fundamental to the viability of the crossing.

As indicated in Table 1, currently the longest ITT constructed to date is the BART Transbay Tubes, which measure 5,825 m. The construction of the BART tubes began in 1967, and was completed in 1969. Construction of the basic tubes lasted two and a half years. To accommodate the schedule the 58 tunnel sections, each measuring 111-metres in length, were placed at a rate of approximately two per month.

This production rate, though exceptional in terms of ITT construction, will be inadequate for the crossing. Using a similar dimension for the length of the elements as the BART tube, approximately 162 elements would be required to complete the crossing. Placed at a rate of 2 per month, 81 months, or 6-3/4 years would be needed for basic tunnel placement – based upon year round production. As marine operations at the crossing site are not possible between January and the end of May each year due to pack ice, elements constructed in this period would be stored until operations could resume. The rate of placement of the elements would have to be increased to 4 per month to compensate.

For the Oresund tunnel linking Denmark and Sweden, elements were constructed at the rate of 2 every 2 months, using the facility shown in Figure 5.2. As the proposed elements for the Strait of Belle Isle crossing will be significantly smaller that those used for the Oresund Tunnel, increasing production to the rate of approximately 2 elements per month should be achievable.

Therefore, the preliminary construction schedule is based upon the assumption that 25 tunnel elements can be fabricated in one year and placed within one marine season between June and December.

Methods of minimizing the overall duration of the project would be investigated in further project phases. These would include:

- Maximizing the length of the tunnel elements, to minimize the number of elements and placement operations
- Dredging at multiple locations simultaneously
- Fabricating and placing the tunnel sections at several locations simultaneously
- Minimizing the project design process through the use of design/build procurement

Water Depth

The depth of the water poses the most significant challenges for the design, construction – in terms of constructability, cost and schedule, and long-term durability of the tunnel elements. As mentioned previously, the deepest ITT under consideration to date is the Bosphorus Crossing in Turkey, with a water depth of 56m. The Strait of Belle Isle Crossing would represent a quantum leap in many of the technologies typically employed for ITT construction. Specific project impacts related to the depth of the water include:

- Dredging feasibility, means and methods
- Tunnel element placement
- Tunnel foundation placement
- Tunnel structure design
- Tunnel joint design
- Tunnel durability

The implications of water depth on the design components and construction operations are expanded below, with the exception of dredging means and methods, which are discussed more fully in Section 6.3. It is believed that though the water depth raises many issues related to the tunnel construction, these can be addressed through use of, or extrapolation of existing technologies, in the belief that these technologies will be more readily defined and available by the time tunnel construction commences.

Tunnel Element Placement

The placement of tunnel elements is a carefully controlled process conducted to tight tolerances to ensure elements are set on the correct alignment, and at the correct level. The placement process is controlled from a console located on top of the element, using digital GPS systems.

The process is a careful one, but is typically conducted as quickly as practically possible to avoid conflicts with shipping, speedier currents, and the chance for inclement weather. The water depth complicates many of these issues . The placement process in the Labrador and Newfoundland Troughs will be lengthy. Maintaining the position of the element as it is lowered into deeper water will be challenging.

Perhaps the most onerous depth induced consideration relates to the use of divers to assist with the placement process. It is likely due to the variation in depth of the crossing, that a number of diving methods can be used. However, for the deeper sections, in excess of 50 metres, the divers will be using a mixture of gases – hydrogen, oxygen and helium which will limit the time they can stay with the element during placement. Decompression chambers will be necessary, and decompression times will be significant, all of which will have adverse cost impacts for the placement operation.

Tunnel Foundation Placement

As with the placement of the tunnel elements, tunnel foundation placement is also required to tight tolerances. The two types of tunnel foundation most commonly used are screeded gravel and pumped sand. The difference between the two, other than material, is that the gravel foundation is prepared prior to tunnel immersion, and the sand foundation is placed after the unit is positioned in the trench.

The gravel foundation is typically placed from a barge, and screeded to line and level using a gantry mounted steel rail. To prepare the foundation to the correct profile it is necessary to stabilize the gantry, through the use of jack-up legs. Large jack-up barges have leg lengths up to 46 metres, some distance short of the required length for the trough sections of the crossing. Though drilling rigs can operate in over 100 metres of water, it is unlikely that they could easily be reconfigured to undertake the foundation preparation. Therefore, it seems likelier that the tunnel foundation would comprise a layer of pumped sand. This will necessitate further use of divers to couple the sand pipe to conduit cast into the tunnel walls or sides.

Tunnel Structure Design

Most underground structures are sized to accommodate imposed loads, and checked to ensure they satisfy project specific requirements against uplift from groundwater. With ITT's the reverse is true. The elements are sized to accommodate the required factors of safety for buoyancy while afloat and when placed. Thereafter strength and serviceability requirements are satisfied. Therefore the dimensions of the tunnel will be the same whether it is submerged in 10 or 100 metres of water. The implications for the structural design of the deeper tunnel sections for the Strait of Belle Isle can be imagined.

However, the proposed tunnels have relatively small spans, and at-depth the water pressures will induce significant axial forces in the structural members which will behave as columns in flexure rather than beams in flexure, helping to keep reinforcement quantities manageable.

The use of a binocular steel tunnel section would enable these high loads to be carried more efficiently in ring compression, but the oversized nature of the elements raises separate, and potentially more critical issues regarding dredge quantities and duration.

The implications of the deeper water for the structure are that reinforcement quantities required – whether steel plate for a steel or SCS tunnel, or high yield bar for a concrete tunnel and hence construction cost will be significantly greater than for a shallower tunnel.

Tunnel Joint Design

ITT's are most commonly jointed using a combination of rubber gaskets, known as the Gina and Omega seals. The construction of the joints is described in Section 6.2. The design and performance of both joints is a function of water depth, but the capacities of existing pre-moulded sections are limited. Calculations will determine whether existing sections can be utilized, based upon initial hydrostatic compressions, plus subsequent movement tolerances for creep, thermal effects and seismic events. It is conceivable that new, larger seals would have to be developed and fabricated specifically for the crossing.

Tunnel Durability

The tunnel will have a service design life of at least 100 years. In reality it will be in service for much longer. At depths of up to and greater than 100 metres, the tunnel structure will be subject to significant hydrostatic pressures. It is likely that the majority of the maintenance issues related to the upkeep of the tunnel will result from water ingress, and its subsequent deterioration of tunnel structure and systems.

It would therefore be prudent to take all necessary steps to prevent water ingress through careful design and detailing of the tunnel structure, even though the proposed concept may cost more initially to construct. The tunnel owner will ultimately realize substantial benefits in the longer term through reduced maintenance.

Geology

ITT's are normally located in waterways such as rivers, harbors, and estuaries, where soft alluvial settlements predominate, and dredging of material is relatively uncomplicated. However, tunnels have been successfully constructed in rock. Dredging for the Oresund Tunnel linking Denmark and Sweden largely involved the removal of limestone. While the surficial rock anticipated for the Strait of Belle Isle does offer some benefits to the ITT construction and durability such as those listed below, overall, in combination with the water depth, the extraction of the rock for the trench will be a laborious process.

- steep side slopes for the trench can be accomplished
- Tunnel bearing pressures can be easily accommodated
- Long term settlements of the tunnel elements will be negligible

Hydrodynamic Conditions

The local conditions in the Strait, related to current, significant wave height and water density can potentially be problematic to the transport and placement of the tunnel elements, and can limit the types of dredging which can be successfully undertaken.

Current

Currently conflicting information exists on current speed. The HVDC Transmission Tunnel Study undertaken in 1980 (Ref. 5) suggests a maximum current of less than 3.5 knots, or 1.8 m/s.

This conflicts with Bedford Institute of Oceanography (BIO) testing results conducted near the tunnel alignment and also undertaken in 1980, which suggested that the maximum current when all components are combined (during spring tides) are as follows:

15m depth	3.6m/s (7.2 kn)
50m depth	2.5m/s (5.0 kn)

Though tunnel elements have been placed successfully in currents approaching 3 m/s, ideal placement operations for an ITT will exist where currents of 1m/s or less prevail.

As the BIO figures are maximums measured during spring, it is more likely that normal maximum currents will be as indicated in the HVDC Transmission Tunnel Study.

As the current of 1.8 m/s is again a maximum figure, it is likely that for significant periods the actual current in the Strait will be much less. Tunnel placement operations must be staged to try and avoid speedier currents, which as stated previously may complicate operations for the deeper elements.

However, though it appears that based upon the velocities indicated, tunnel placement is feasible, a more complete understanding of the current regime will be necessary during design development to assess current induced forces on the elements. If currents remain as high as indicated above for significant periods, then the achievable length of the ITT elements will be reduced.

Wave Height

In exposed offshore areas, swell and waves can have a number of effects on the transport and immersion of the tunnel elements, which can be considerable in magnitude. These include:

- Waves will cause significant longitudinal bending moments which must be accommodated in the design of the tunnel reinforcement
- Wave action can induce motions of the tunnel element with significant amplitude, if the wave excitation frequency and natural frequency of the floating tunnel are similar.
- Waves overtopping a tunnel element with small freeboard can induce a longitudinal pitch of the element, which can cause rapid loss of stability, resulting in the unit being pulled underwater.

Based upon information collected to date, and the results of a wave hindcast analysis it is estimated that during the period June through August, waves with heights of 1m or greater would occur 40 per cent of the time. Furthermore, waves with heights of 2 m or more would occur less than 2.5 per cent of the time, and the maximum significant wave height would approach 3 metres.

To ensure that the ITT elements can be safely transported and placed in such conditions, extensive hydraulic modeling would be recommended.

Water Density

Water density can greatly effect the placement of ITT elements in tidal waterways where fresh and salt-water mix, or where sediment has remained in suspension from the dredging process creating a more dense water layer. Neither of these conditions should exist for this crossing, where a relatively constant density is anticipated.

Meteorological Factors

Pressure, wind, rain, temperature and visibility will all have an effect upon the transport and placement of the tunnel elements. However, the most significant meteorological factor related to the ITT design and construction is ice.

The extent and duration of pack-ice coverage at the site is approximately known. The icing over of the Strait will typically result in the suspension of all marine activities for the period between January and May. The implications of the pack-ice on the construction schedule are documented elsewhere in the report.

The passage of icebergs through the site will also be of great concern. The random nature of the iceberg frequency and location will be of concern for tunnel transport and placement operations. An early warning system will be necessary to ensure there is no risk of impact to a tunnel element during the placement process. The in-place tunnel structure will be located at a depth sufficient to avoid the effects of iceberg scour over the design life of the structure.

Environmental Factors

The Strait of Belle Isle is a well recognized migration route for many species of whales and other marine mammals. Whales including humpback, fin, pothead, and minke are frequently sighted in the Strait of Belle Isle during summer and early fall. Killer whales are occasionally spotted. Porpoises and dolphins are also common.

The migration of these species will occur concurrently with the dredging process, which is largely anticipated to be carried out using underwater blasting. To satisfy environmentalists blasting may have to be suspended when whales are sighted in the close vicinity of the tunnel alignment. The effects of this random event upon the tunnel construction schedule may be significant.

6.5 Preferred Construction Methods

It would be unwise at this early stage to rule out, or conclusively propose one single method of construction for the ITT's without undertaking a more rigorous study involving preliminary analysis for each option.

However, having considered the site specific constraints, a brief list of advantages and disadvantages for each construction method has been compiled leading to a preliminary recommendation for a construction method. This method has subsequently been used in the derivation of the preliminary construction cost and construction schedule for the project.

Concrete Tunnel

Advantages	*Disadvantages*
Economic cross-section, tailored to suit traffic envelope, thus minimizing dredging quantities. *Changes in cross section at ventilation zones can be easily accommodated.* *Longest tunnel elements minimizes the number of transport, placement and jointing operations.* *Suitable casting facilities available.* *Appropriate labor available.*	*Concrete is a brittle material by nature with a tendency to crack raising issues of long-term durability of structure and internal systems.* *Long tow over a period of 4-5 days will be required from the identified casting facilities, with higher risk to schedule due to inclement weather.* *Elements will be heavily reinforced to accommodate imposed loads.*

Table 6.2: Advantages and Disadvantages of Concrete Tunnel Construction

Steel Shell Tunnel

Advantages	Disadvantages
Tunnel section will carry the significant imposed loads efficiently in hoop compression. Watertightness achieved through continuous welding of shell plate. No special casting facility required. The element fabrication can be conducted on any available land adjacent to a waterway - which could be at the tunnel site. Rapid fabrication of steel assemblies gives potential schedule benefits. Steel elements can be barge mounted to minimize effects of wave induced bending, and inclement weather, making long tows in open water less risky.	Tunnel elements are short due to imposed stresses during concreting operation while afloat, maximizing costly tunnel transport, placement, and jointing operations. The circular profile of the steel shell is not well suited to the traffic clearance profile, resulting in inefficient use of space, and hence additional cost. The tunnel elements will have the deepest profile, even with a flat invert, resulting in increased dredge quantities versus the other options – with inherent schedule impacts. Changes in cross-section of the circular section at ventilation zones cannot be easily accommodate, and would require specialized fabrication. Steel prices are currently high, and climbing rapidly. The cost for the steel shell tunnel is likely to be higher than the concrete tunnel, and the estimate provided will be most susceptible to rapid change due to the volatility of steel prices. Cathodic protection will be required to maintain long-term durability of structure.

Table 6.3: Advantages and Disadvantages of Steel Shell Tunnel Construction

Composite (SCS) Tunnel

Advantages	Disadvantages
Economic cross-section, tailored to suit traffic envelope, thus minimizing dredging quantities. Changes in cross section at ventilation zones can be easily accommodated. Watertightness achieved through continuous welding of shell plate. No special casting facility required. The element fabrication can be conducted on any available land adjacent to a waterway - which could be at the tunnel site. Rapid fabrication of steel assemblies, in conjunction with pouring of highly fluid concrete gives potential schedule benefits.	Structure behaves in bending/shear unlike the circular steel shell tunnel, which carries loads in compression. Steel plate thickness required to accommodate impose loads may be prohibitively thick. Steel prices are currently high, and climbing rapidly. The cost for the steel shell tunnel is likely to be higher than the concrete tunnel, and the estimate provided will be most susceptible to rapid change due to the volatility of steel prices. Cathodic protection will be required to maintain long-term durability of structure.

Steel elements can be barge mounted to minimize effects of wave induced bending, and inclement weather, making long tows in open water less risky.	*Fireproofing of the internal steel plate will be necessary to maintain structural integrity during an incident.*

Table 6.4: Advantages and Disadvantages of Composite (SCS) Tunnel Construction

Conclusion

On the basis of the preliminary assessment undertaken, it would appear that either the concrete or SCS options present the most realistic solutions for an ITT crossing for either the road or rail tunnel. However, based upon the prevailing local labor conditions, it is the concrete option which offers the preferred solution. Given the volatility in current steel prices, the concrete option can be estimated most accurately for the level of study undertaken, and the estimate developed will be valid for longer.

The one major drawback of the concrete tunnel - its tendency to crack – does raise serious durability concerns, given the depth at which the tunnel shall ultimately be placed. To overcome such concerns, it is recommended that a continuous steel plate of nominal thickness only, 6 mm, is used as a waterproofing membrane for the tunnel. The plate will be welded watertight at joints. The additional construction outlay for the plate and welding, will be more than offset by the design life of the tunnel, and the savings on maintenance costs achieved.

7. Tunnel Systems Requirements

The tunnels must accommodate a number of mechanical, electrical, and security systems to maintain serviceability during operating conditions, and to maintain a tenable environment in the event of an incident. Items to be incorporated into the tunnel will include the following:

Mechanical

- Ventilation, including HVAC for egress corridor
- Drainage. The profile of the ITT follows the bed of the Straits, requiring multiple low point sumps.
- Sump pumps

Electrical

- Lighting, including lighting for egress corridor
- Heat
- Normal and emergency power supply and distribution
- SCADA

Fire and Life Safety/Security

- Standpipes
- Extinguishing systems
- Emergency telephone
- Heat and smoke detectors
- Emergency walkways
- CCTV

Corrosion Protection

- Cathodic protection, using sacrificial anodes or impressed current for SCS and steel options only. For the concrete tunnel the steel plate will be sacrificial.

Other

The tunnel may accommodate HVDC power lines. These lines and their potential locations have been indicated upon the preliminary tunnel cross-sections. Additional space will also exist which could potentially carry additional utilities and conduit within the available void space.

Rail Systems

Specific to the rail operation, multiple additional systems will be necessary. These will include:

- Track
- Traction power
- Signaling
- Communications

8. Costs

Preliminary construction cost estimates for both road and rail alternatives have been developed, based upon the preferred concrete construction methodology identified in Section 6.4, and indicated upon the accompanying drawings. The cost estimate is based upon information gleaned from several sources including on-line databases, historical project information, and from discrete enquiries made to vendors and equipment owners.

8.1 Construction

The Strait of Belle Isle crossing will be a unique endeavour using ITT methods, requiring extrapolation of current construction technologies, particularly in terms of underwater excavation and blasting, which would be undertaken on a largely unprecedented scale. Therefore, while every effort has been made to accurately define a unit rate for dredging, some uncertainty does exist over the price.

Cost Estimate Assumptions

In developing the cost estimate, multiple sources of information have been used including:

- Enquiry to Bull Arm Site Corporation for lease costs for drydock, batching plant, reinforcement shop and the deep-water storage site.
- Extensive use of the Newfoundland Heavy Construction Cost database, available through www.get-a-quote.com for principal quantities including cast-in-place and precast concrete, formwork, reinforcement, structural steel, surfacing etc.
- Use of historic information for tunnel joint prices for Gina and Omega seals, escalated to 2004 prices, with applied contingency for anticipated larger seal requirements.
- Rates for dredging, and backfilling for the tunnel are based upon conversations with multiple dredging contractors.
- Due to pack ice, remobilization costs will be incurred each dredging season and have therefore been included in the cost estimates

Derivation of Quantities

As stated previously, the costs of the ITT have been developed based upon the use of concrete tunnel technology. To derive basic tunnel quantities, in conjunction with the proposed traffic clearance envelopes and stipulated ventilation requirements, minimum factors of safety for the ITT sections while afloat and in-place were assumed, which allowed the development of concrete member sizes. The only figure which has been estimated id that of reinforcement. Concrete ITT's at normal depth will typically have a reinforcement density in the region of 110 kg/m^3. As can be seen from the cost spreadsheets in Appendix A, far higher reinforcement densities have been assumed, to reflect the higher imposed loadings presented by the deeper water.

For the dredged trench, representative sections were developed, with variations in the depth of the overburden or surficial deposits. As mentioned in Section 4, on average the overburden deposits are between 2.5 and 3m thick. The deposits themselves vary from the relatively weak and unstable glaciomarine - marine deposits to the much more stable sands, gravels, and tills. Correspondingly, the weaker soils will be cut back at shallower angles to maintain trench stability.

Sections were developed for each of the tunnel geometry options, providing high-end and low-end dredge quantities by varying the overburden geology and thickness. Side slope angles were in accordance with the recommendations made in section 4.

The two extreme values were averaged to obtain the quantity estimate. At the same time this approach provided an indication of the influence that overburden variations could have on the quantities and hence costs. It is conceivable that within a certain area the cross-sectional area of the trench could be significantly higher or lower than predicted. However until the surficial deposits are investigated further, and their limits more accurately defined, this "averaging" approach is considered the most appropriate.

8.2 Operations & Maintenance

Operations Costs

Primary sources for operations costs will include the following:

- Power consumption for tunnel systems – primarily the tunnel ventilation and pumped drainage system, but also for traction power for the rail option only.
- Salaries for personnel such as a tunnel manager, and tunnel staff employed for monitoring, cleaning, and routine maintenance functions, within the tunnel control buildings.

Power usage can be estimated based upon the proposed equipment. Salaries for employees can also be calculated based upon prevailing wage rates for the Province.

Maintenance Costs

Through the use of the external steel plate, little water ingress into the ITT is anticipated. Little degradation of the tunnel structure will therefore be expected for many years. Sources of structural maintenance will largely be limited to portal and approach areas including the control buildings, which are exposed to the brunt of the prevailing weather conditions. Some deterioration within the tunnel may occur at connections to ventilation ducts from the control buildings. Costs for such maintenance is hard to define.

More regular maintenance and replacement costs will be required for the many tunnel systems, which with design lives of 15-20 years, will undoubtedly be replaced several times over the life of the structure, and based upon current roadway and rail configurations, may require closure of the tunnel for prolonged periods. This loss of tunnel revenue must also be added to the maintenance cost.

9. Construction Schedule

Preliminary construction schedules have been prepared for the road and rail tunnels. The methodology and assumptions made in arriving at the presented schedules, are listed below.

As has been mentioned throughout the report, the major critical path items for the development of a feasible timeline for the ITT construction are:

- Dredging of the trench
- Fabrication of the tunnel elements
- Placement of the tunnel elements

The tunnel placement operation has been used as the basis for deriving the tunnel construction duration. The Strait is accessible in the months of June to December, typically comprising a period of approximately 30 weeks.

It has been assumed that in these months, tunnel elements will be placed approximately at the rate of one per week. However, provision should be made within this schedule for factors such as the required tow length from identified facilities, inclement weather, including prolonged winter, and drifting icebergs. For these reasons we have assumed that 25 elements will be placed per season. This remains a demanding figure.

Other assumptions include:

- Sufficient dredging must be performed each season to accommodate placement of 25 elements. The dredging operation will be continuous, 24 hours per day, 7 days per week. It is also assumed that multiple dredgers will be in operation at any given time.
- Similarly, suitable fabrication facilities can be leased or constructed, and sufficient skilled labor can be identified to accommodate the construction of 25 elements per year. Due to the size of the project, the potential exists for more than one fabrication facility to be engaged. It is assumed that sufficient facilities can be available to meet the recommended production requirement.
- A tunnel element length of 150 metres has been assumed. This is longer than average, but within current technological limits. The longest concrete elements to date, for the Oresund Tunnel, measure 175 metres, and the longest steel plated elements measure 135 metres approximately. The 150-metre length is a usable figure on the basis that further study would be necessary to fully define a preferred construction method.
- It is assumed that Newfoundland will provide the majority of the fabrication facilities, and will be the primary source of labor for the project. Therefore, it is assumed that the construction of the Newfoundland approach could proceed more rapidly, and be available sooner to interface with the ITT. Subsequently, placement of tunnel elements will proceed from the Newfoundland side, enabling internal concrete works to begin from this location.
- Approach construction includes cut and cover tunnel sections including ITT interface, open trough sections, and retaining walls or stabilized rock cuts to grade as necessary.
- Internal fitting-out of the tunnel can continue year-round.
- Internal concreting of the tunnel sections, including emergency corridor, and roadway ballast or track slab, will proceed after placement of several elements.

10. Results of Preliminary Risk Assessment

The history of ITT construction reveals few major incidents or events which have had an effect on the projects themselves or third parties. However, two major incidents which are worthy of attention have occurred in the recent past. These incidents are referenced in Table 9.1 below. The risks involved with both all construction options are similar and can be grouped under the headings of cost, time/schedule, technical matters and the towing and placement process.

Risk	*Description*	*Mitigation*
Cost	*Unforeseen ground conditions, such as higher than anticipated rock elevation, or contaminated deposits are encountered.*	*Risks can be minimized with appropriate level of site investigation and testing of deposit samples.*
Schedule	*Contractor is unable to locate suitable fabrication or casting facility.*	*Client may see fit to make advance arrangements for casting basin site or identify suitable fabrication facilities and charge contractor for the use of the site.*
	Cold winter results in pack-ice coverage beyond May.	*Contingency plan for schedule recovery, including use of additional equipment will be required.*
	Poor weather prevents transport and placement of tunnel elements	*Contingency plan for schedule recovery.*
	Iceberg interference with tunnel element immersion	*Early warning system to indicate presence of approaching icebergs in path of tunnel. Either suspend placement operation for icebergs, or divert growlers and bergy bits.*
	Environmental limitations on dredging timing and duration to protect habitat.	*Obtain advance information on such restrictions and make all parties aware of construction envelopes prior to bidding contract.*
	Fast moving currents depositing sediment on trench bottom.	*Minimizing period for which trench is open before element placement will keep sediment flow to a minimum. Cleaning off trench prior to placement of elements will be necessary.*
	Plant/equipment failure	*For construction activities with a risk of plant failure, back up equipment should be made available to replace defective machinery as necessary.*
Technical Matters	*The tunnel may be subject to a number of extreme conditions over its intended design life. These would include the following:*	*The risks of extreme loads can be minimized through appropriate design, detailing, and vertical alignment selection for the tunnel*

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Schedule	*Contractor is unable to locate suitable fabrication or casting facility.*	*Client may see fit to make advance arrangements for casting basin site or identify suitable fabrication facilities and charge contractor for the use of the site.*
	Cold winter results in pack-ice coverage beyond May.	*Contingency plan for schedule recovery, including use of additional equipment will be required.*
	Poor weather prevents transport and placement of tunnel elements.	*Contingency plan for schedule recovery.*
	Iceberg interference with tunnel element immersion.	*Early warning system to indicate presence of approaching icebergs in path of tunnel. Either suspend placement operation for icebergs, or divert growlers and bergy bits.*
	Environmental limitations on dredging timing and duration to protect habitat.	*Obtain advance information on such restrictions and make all parties aware of construction envelopes prior to bidding contract.*
	Fast moving currents depositing sediment on trench bottom.	*Minimizing period for which trench is open before element placement will keep sediment flow to a minimum. Cleaning off trench prior to placement of elements will be necessary.*
	Plant/equipment failure.	*For construction activities with a risk of plant failure, back up equipment should be made available to replace defective machinery as necessary.*
Technical Matters	*The tunnel may be subject to a number of extreme conditions over its intended design life. These would include the following:*	*The risks of extreme loads can be minimized through appropriate design, detailing, and vertical alignment selection for the tunnel*

	• Iceberg scour • Sunken ship • Dragging/falling anchor • Extreme high tide • Flooded tunnel • Explosion • Fire • Loss of tunnel support due to seismic event.	*structure. Tunnel detailing will be sufficient to remain serviceable for a fire of agreed intensity and duration. Tunnel design will investigate conditions where tunnel support has been lost over an agreed length.*
	Interface joint failure between ITT and land approach.	*The interface between the ITT and approach must be recognized as a critical design element. A contractors value-engineering proposal on the Fort Point Channel ITT in Boston resulted in the failure of a closure joint, resulting in inundation of the adjacent excavation, loss of months of schedule with resulting cost impacts totalling millions of dollars.*
Towing and Placement	*Sinking of tunnel element during towing and immersion. This could be a result of the tunnel being overtopped by a series of significant waves, or failure of a bulkhead.*	*Check all projected weather and tidal information prior to towing for a period of calm for the duration of the tow, and maintain such checks during the towing process. A bulkhead failure is an extreme event, but happened during construction of the Oresund Tunnel. The element sank, but was recovered. Quality control and adequate supervision during construction is necessary.*
	Catastrophic failure of tunnel element during long tow involving significant wave heights and wave induced bending moments.	*Tunnel shall be designed with sufficient longitudinal strength to accommodate wave induced bending moments. Tunnel route shall be carefully selected to provide safe havens should rough waters be predicted during the towing process.*
	Collapse of dredged trench.	*Determine safe slopes from testing Minimize duration of open trench prior to tunnel element placement.*

Table 10.1: ITT Preliminary Risk Assessment

Major risks to the safe and successful construction of the project can be identified and quantified during the design process through risk analysis and constructability review procedures leading to the development of strategies to mitigate risk through design or allocation of contingency.

11. References

1. Strait of Belle Isle Navigation Chart, Sheet 14415, Defense Mapping Agency Hydrographic/Topographic Center, 1991.
2. White Rose Development Application Volume 1 Report, Husky Energy, January 2001.
3. Iceberg Scour Risk in the Strait of Belle Isle, C-Core Report R-04-004-011, April 2004.
4. Surficial and Bedrock Geology Beneath the Strait of Belle Isle in the vicinity of a Proposed Power-Cable Crossing, C.M.T. Woodworth-Lynas, J.Y. Guigne, and E.L. King.
5. Strait of Belle Isle Crossing HVDC Transmission Tunnel Scheme, Engineering Report, Cost Estimate & Construction Schedule, Report No. 11.99.05, SNC-Lavalin Newfoundland Ltd., March 1980.

Appendix A
Construction Cost Estimates

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Strait of Belle Isle Crossing

Preliminary Immersed Tube Tunnel Cost Estimate - Rail Tunnel

Item	Unit	Quantity	Rate	Total
General Details				
Tunnel Length	18,000	metres		
Tunnel Element Length	150	metres	No. Elements =	120
1 Tunnel Element Fabrication				
Miscellaneous				
Mobilisation/demobilisation @ 3% of subtotal structure cost	ls	1	$41,116,424.03	$41,116,424
Fabrication facility lease (2 facilities assumed @ 5.5 yrs each)	year	11	$3,500,000.00	$38,500,000
Concrete				
Structural grade 4,000 psi placed by pump - slab on grade	m^3	165,150	$157.32	$25,981,398
Structural grade 4,000 psi placed by pump - elevated slab	m^3	135,270	$169.62	$22,944,497
Structural grade 4,000 psi placed by pump - walls	m^3	251,100	$175.31	$44,020,341
External Protection Layer, 2,500 psi, placed by pump	m^3	22,410	$153.34	$3,436,349
Keyed control joints transverse (at 20m centres approx)	m^2	32,310	$13.25	$428,108
Keyed control joints longitudinal (2 total at base/wall junction)	m	36,000	$13.25	$477,000
Curing, sprayed membrane, internal surfaces only	m	505,800	$1.32	$667,656
Formwork				
Walls, multiple use forms	m^2	626,400	$78.92	$49,435,488
Elevated Slab, multiple use forms	m^2	113,400	$81.48	$9,239,832
Reinforcement: grade 60 high yield				
Wall & Slab reinforcing, 130 kg/m^3	tonnes	71,698	$1,501.87	$107,680,475
Bending, cutting & splicing	tonnes	71,698	$270.44	$19,389,899
Waterproofing Membrane				
Steel skin plate, A36, 8 mm thick	tonnes	30,436	$3,132.11	$95,328,117
Shear connectors, 150 mm x 12 mm, including stud welding	each	2,592,000	$0.10	$259,200
Automated Welding	m	309,240	$14.86	$4,595,306
Tunnel Joints				
Structural Steel End Frames (2/element)				
Embedded steel beams, 180 kg/m	tonnes	1,542	$2,709.04	$4,177,340
Front plates, 20 mm thick	tonnes	677	$3,132.11	$2,119,812
Gina fabrication, installation	each	120	$18,524.00	$2,222,880
Omega fabrication, installation & testing	each	120	$23,335.00	$2,800,200
Joint concrete, shear keys, cover plates etc.	each	120	$20,000.00	$2,400,000
			Page Total	***$477,220,322***

Hatch Mott MacDonald

Strait of Belle Isle Crossing

Preliminary Immersed Tube Tunnel Cost Estimate - Rail Tunnel

Item	Unit	Quantity	Rate	Total
			Total Brought Forward	$477,220,322
Temporary Works Items (Per Element)				
Structural Steel Bulkheads (2/element)				
Support Columns, 250 kg/m	tonnes	1,920	$2,709.04	$5,201,357
Skin plate, 12 mm thick	tonnes	1,440	$3,132.11	$4,510,238
Plate siffening angle, 18 kg/m	tonnes	360	$3,174.03	$1,142,651
Embedded perimeter angle, 18 kg/m	tonnes	120	$3,174.03	$380,884
Welding	m	53,880	$14.86	$800,657
Field Welding Premium	m	53,880	$40.06	$2,158,433
Misc. Structural Steel				
Alignment & pulling brackets etc., 5 tonnes per element	tonnes	600	$3,132.11	$1,879,266
Ballast Tanks (2/element)				
Steel support columns, 100 kg/m	tonnes	2,640	$2,709.04	$7,151,866
Timber lagging, 150 mm deep	m^2	42,768	$60.40	$2,583,187
Membrane liner	m^2	42,768	$27.84	$1,190,661
2 *Tunnel Transport & Placement*				
Element Transport: tug rental etc.	each	120	$500,000.00	$60,000,000
Element placement: barge/pontoons,divers, survey etc.	each	120	$1,000,000.00	$120,000,000
Tunnel Closure				
Underwater joint completion	each	1	$2,500,000.00	$2,500,000
3 *Internal Structural & Civil Finish Works*				
Ballast				
Track ballast concrete, 2,500 psi, placed by chute	m3	54,000	$140.06	$7,563,240
Track ballast reinforcement: welded wire fabric 6 x 6 x #4, 2.8kg/m^2	m^2	81,000	$9.36	$758,160
Deduct in excess of 4.5 tonnes	tonne	222	-$41.01	-$9,104
Emergency corridor sand/cement mix for HVDC cables	m3	20,250	$140.06	$2,836,215
Precast Divider for Emergency Egress Corridor				
Panel fabrication, 8" thick, incuding reinformcement & lifting points	m^2	103,500	$196.98	$20,387,430
Panel setting, based upon max panel weight of 6 tons.	each	9,000	$285.70	$2,571,300
Seal and caulk panels	m	36,000	$5.48	$197,280
Sprayed fireproofing for precast panels	m^2	103,500	$20.77	$2,149,695
			Page Total	**$723,173,737**

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Strait of Belle Isle Crossing
Preliminary Immersed Tube Tunnel Cost Estimate - Rail Tunnel

Item	Unit	Quantity	Rate	Total
			Total Brought Forward	$723,173,737
4 Marine Operation				
Dredging				
Mobilization/Demobilzation per season, 6 seasons, 2 vessels	each	24	$150,000.00	$0
Stage 1 bulk dredging of material	m3	4,028,049	$84.00	$0
Stage 2 fine tolerance dredging & additional trench cleaning	m3	604,207	$43.00	$665,000,000
Foundation and Backfill				
Screeded gravel foundation	m3	157,275	$35.00	$5,504,625
Selected locking fill	m3	377,496	$35.00	$13,212,360
Backfill	m3	550,368	$35.00	$19,262,880
Rock armor protection	m3	470,790	$51.00	$24,010,290
Subtotal Structure Cost				**$1,450,163,892**
Tunnel MEP Systems	ls	10 % of structure cost		$145,016,389
Rail Systems	ls	15 % of structure cost		$217,524,584
Contingency on Tunnel Costs	ls	30% of subtotal structure cost		$435,049,168
"Soft" Costs				
Engineers design & construction supervision fee	ls	10% of construction cost		$224,775,403
Estimated Construction Cost				**$2,472,529,435**
Estimated Construction Cost per linear metre				**$137,363**

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Strait of Belle Isle Crossing

Preliminary Immersed Tube Tunnel Cost Estimate - Road Tunnel

Item	*Unit*	*Quantity*	*Rate*	*Total*
General Details				
Tunnel Length	18,000	metres		
Tunnel Element Length	150	metres	No. Elements =	120
The cross sectionof the tunnel element varies across three ventilation zones.				
Zone 1 from stations 0 to 1+800, and 16+200 to 18+000	3,600	metres	24	elements
Zone 2 from stations 1+800 to 6+150, and 11+850 to 16+200	8,700	metres	58	elements
Zone 3 from stations 6+150 to 11+850	5,700	metres	38	elements
1 *Miscellaneous*				
Mobilisation/demobilisation @ 3% of subtotal structure cost	ls	1	$5,547,109.65	$5,547,110
Fabrication facility lease (2 facilities assumed @ 5.5 yrs each)	year	11	$3,500,000.00	$38,500,000
2 *Tunnel Element Fabrication - Zone 1*				
Concrete				
Structural grade 4,000 psi placed by pump - slab on grade	m^3	94,968	$157.32	$14,940,366
Structural grade 4,000 psi placed by pump - elevated slab	m^3	80,640	$169.62	$13,678,157
Structural grade 4,000 psi placed by pump - walls	m^3	58,572	$175.31	$10,268,257
External Protection Layer, 2,500 psi, placed by pump	m^3	10,746	$153.34	$1,647,792
Keyed control joints transverse (at 20m centres approx)	m	10,161	$13.25	$134,633
Keyed control joints longitudinal (2 total at base/wall junction)	m	7,200	$13.25	$95,400
Curing, sprayed membrane, internal surfaces only	m	210,600	$1.32	$277,992
Formwork				
Walls, multiple use forms	m^2	146,700	$78.92	$11,577,564
Elevated Slab, multiple use forms	m^2	61,920	$74.27	$4,598,798
Reinforcement: grade 60 high yield				
Wall & Slab reinforcing, 150 kg/m^3	tonnes	35,127	$1,501.87	$52,756,187
Bending, cutting & splicing	tonnes	35,127	$270.44	$9,499,746
Waterproofing Membrane				
Steel skin plate, A36, 6 mm thick	tonnes	19,143	$3,132.11	$59,957,982
Shear connectors, 150 mm x 12 mm, including stud welding	each	812,880	$0.10	$81,288
Automated Welding	m	91,044	$14.86	$1,352,914
Tunnel Joints				
Structural Steel End Frames (2/element)				
Embedded steel beams, 180 kg/m	tonnes	480	$2,709.04	$1,300,339
Front plates, 20 mm thick	tonnes	216	$3,132.11	$676,536
Gina fabrication, installation	each	24	$29,128.00	$699,072
Omega fabrication, installation & testing	each	24	$36,693.00	$880,632
Joint concrete, shear keys, cover plates etc.	each	24	$20,000.00	$480,000
			Page Total	***$228,950,765***

Item	Unit	Quantity	Rate	Total
			Toal Brought Forward	$228,950,765
Temporary Works Items (Per Element)				
Structural Steel Bulkheads (2/element)				
Support Columns, 250 kg/m	tonnes	936	$2,709.04	$2,535,661
Skin plate, 12 mm thick	tonnes	480	$3,132.11	$1,503,413
Plate siffening angle, 18 kg/m	tonnes	168	$3,174.03	$533,237
Embedded perimeter angle, 18 kg/m	tonnes	96	$3,174.03	$304,707
Welding	m	22,656	$14.86	$336,668
Field Welding Premium	m	22,656	$40.06	$907,599
Misc. Structural Steel				
Alignment & pulling brackets etc., 5 tonnes per element	tonnes	120	$3,132.11	$375,853
Ballast Tanks (2/element)				
Steel support columns, 100 kg/m	tonnes	672	$2,709.04	$1,820,475
Timber lagging, 150 mm deep	m^2	10,776	$60.40	$650,870
Membrane liner	m^2	10,776	$27.84	$300,004
3 Internal Structural & Civil Finish Works - Zone 1				
Ballast				
Road ballast concrete, 2,500 psi, placed by chute	m3	18,810	$140.06	$2,634,529
Road ballast reinforcement: welded wire fabric 6 x 6 x #4, 2.8kg/m^2	m^2	25,200	$9.36	$235,872
Deduct in excess of 4.5 tonnes	tonne	66	-$41.01	-$2,707
Emergency corridor sand/cement mix for HVDC cables	m3	4,410	$140.06	$617,665
Precast Divider for Emergency Egress Corridor & Vent Duct				
Panel fabrication, 8" thick, incuding reinformcement & lifting points	m^2	50,490	$196.98	$9,945,520
Panel setting, based upon max panel weight of 6 tons.	each	3,600	$285.70	$1,028,520
Seal and caulk panels	m	14,400	$5.48	$78,912
Sprayed fireproofing for precast panels	m^2	50,490	$20.77	$1,048,677
Roadway Surfacing				
Surface treatment, prepare & clean surface	km	3.6	$4,188.69	$15,079
Bituminous surface course, 75 mm thick	m3	1,890	$75.08	$141,901
4 Tunnel Element Fabrication - Zone 2				
Concrete				
Structural grade 4,000 psi placed by pump - slab on grade	m^3	169,563	$157.32	$26,675,651
Structural grade 4,000 psi placed by pump - elevated slab	m^3	149,205	$169.62	$25,308,152
Structural grade 4,000 psi placed by pump - walls	m^3	106,401	$175.31	$18,653,159
External Protection Layer, 2,500 psi, placed by pump	m^3	20,384	$153.34	$3,125,698
Keyed control joints transverse (at 20m centres approx)	m^2	20,097	$13.25	$266,285
Keyed control joints longitudinal (2 total at base/wall junction)	m	17,400	$13.25	$230,550
Curing, sprayed membrane, internal surfaces only	m	337,125	$1.32	$445,005
			Page Total	$328,667,722

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Strait of Belle Isle Crossing

Preliminary Immersed Tube Tunnel Cost Estimate - Road Tunnel

Item	Unit	Quantity	Rate	Total
			Toal Brought Forward	$328,667,722
Formwork				
Walls, multiple use forms	m^2	241,860	$78.92	$19,087,591
Elevated Slab, multiple use forms	m^2	117,885	$74.27	$8,755,319
Reinforcement: grade 60 high yield				
Wall & Slab reinforcing, 200 kg/m^3	tonnes	85,034	$1,501.87	$127,709,713
Bending, cutting & splicing	tonnes	85,034	$270.44	$22,996,541
Waterproofing Membrane				
Steel skin plate, A36, 6 mm thick	tonnes	19,140	$3,132.11	$59,948,585
Shear connectors, 150 mm x 12 mm, including stud welding	each	1,642,560	$0.10	$164,256
Automated Welding	m	186,528	$14.86	$2,771,806
Tunnel Joints				
Structural Steel End Frames (2/element)				
Embedded steel beams, 180 kg/m	tonnes	986	$2,709.04	$2,671,113
Front plates, 20 mm thick	tonnes	464	$3,132.11	$1,453,299
Gina fabrication, installation	each	58	$24,355.00	$1,412,590
Omega fabrication, installation & testing	each	58	$30,680.00	$1,779,440
Joint concrete, shear keys, cover plates etc.	each	58	$20,000.00	$1,160,000
Temporary Works Items (Per Element)				
Structural Steel Bulkheads (2/element)				
Support Columns, 250 kg/m	tonnes	1,682	$2,709.04	$4,556,605
Skin plate, 12 mm thick	tonnes	870	$3,132.11	$2,724,936
Plate siffening angle, 18 kg/m	tonnes	348	$3,174.03	$1,104,562
Embedded perimeter angle, 18 kg/m	tonnes	116	$3,174.03	$368,187
Welding	m	77,024	$14.86	$1,144,577
Field Welding Premium	m	77,024	$40.06	$3,085,581
Misc. Structural Steel				
Alignment & pulling brackets etc., 5 tonnes per element	tonnes	290	$3,132.11	$908,312
Ballast Tanks (2/element)				
Steel support columns, 100 kg/m	tonnes	1,508	$2,709.04	$4,085,232
Timber lagging, 150 mm deep	m^2	24,360	$60.40	$1,471,344
Membrane liner	m^2	24,360	$27.84	$678,182
5 Internal Structural & Civil Finish Works - Zone 2				
Ballast				
Road ballast concrete, 2,500 psi, placed by chute	m3	36,540	$140.06	$5,117,792
Road ballast reinforcement: welded wire fabric 6 x 6 x #4, 2.8kg/m^2	m^2	60,900	$9.36	$570,024
Deduct in excess of 4.5 tonnes	tonne	166	-$41.01	-$6,808
Emergency corridor sand/cement mix for HVDC cables	m3	10,658	$140.06	$1,492,689
			Page Total	$605,879,194

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Strait of Belle Isle Crossing

Preliminary Immersed Tube Tunnel Cost Estimate - Road Tunnel

Item	Unit	Quantity	Rate	Total
			Toal Brought Forward	**$605,879,194**
Precast Divider for Emergency Egress Corridor				
Panel fabrication, 8" thick, incuding reinformcement & lifting points	m^2	137,460	$196.98	$27,076,871
Panel setting, based upon max panel weight of 6 tons.	each	13,050	$285.70	$3,728,385
Seal and caulk panels	m	52,200	$5.48	$286,056
Sprayed fireproofing for precast panels	m^2	167,040	$20.77	$3,469,421
Roadway Surfacing				
Surface treatment, prepare & clean surface	km	8.7	$4,188.69	$36,442
Bituminous surface course, 75 mm thick	m3	4,568	$75.08	$342,928
6 *Tunnel Element Fabrication - Zone 3*				
Concrete				
Structural grade 4,000 psi placed by pump - slab on grade	m^3	71,193	$157.32	$11,200,083
Structural grade 4,000 psi placed by pump - elevated slab	m^3	58,767	$169.62	$9,968,059
Structural grade 4,000 psi placed by pump - walls	m^3	55,475	$175.31	$9,725,366
External Protection Layer, 2,500 psi, placed by pump	m^3	9,320	$153.34	$1,429,052
Keyed control joints transverse (at 20m centres approx)	m^2	10,616	$13.25	$140,665
Keyed control joints longitudinal (2 total at base/wall junction)	m	11,400	$13.25	$151,050
Curing, sprayed membrane, internal surfaces only	m	169,005	$1.32	$223,087
Formwork				
Walls, multiple use forms	m^2	152,190	$78.92	$12,010,835
Elevated Slab, multiple use forms	m^2	52,440	$74.27	$3,894,719
Reinforcement: grade 60 high yield				
Wall & Slab reinforcing, 150 kg/m^3	tonnes	27,815	$1,501.87	$41,774,946
Bending, cutting & splicing	tonnes	27,815	$270.44	$7,522,366
Waterproofing Membrane				
Steel skin plate, A36, 6 mm thick	tonnes	9,975	$3,132.11	$31,242,797
Shear connectors, 150 mm x 12 mm, including stud welding	each	424,650	$0.10	$42,465
Automated Welding	m	99,465	$14.86	$1,478,050
Tunnel Joints				
Structural Steel End Frames (2/element)				
Embedded steel beams, 180 kg/m	tonnes	504	$2,709.04	$1,365,031
Front plates, 20 mm thick	tonnes	222	$3,132.11	$696,268
Gina fabrication, installation	each	38	$19,221.00	$730,398
Omega fabrication, installation & testing	each	38	$24,213.00	$920,094
Joint concrete, shear keys, cover plates etc.	each	38	$20,000.00	$760,000
			Page Total	**$776,094,627**

Hatch Mott MacDonald

Strait of Belle Isle Crossing

Preliminary Immersed Tube Tunnel Cost Estimate - Road Tunnel

Item	Unit	Quantity	Rate	Total
			Toal Brought Forward	**$776,094,627**
Temporary Works Items (Per Element)				
Structural Steel Bulkheads (2/element)				
Support Columns, 250 kg/m	tonnes	749	$2,709.04	$2,027,987
Skin plate, 12 mm thick	tonnes	371	$3,132.11	$1,160,447
Plate siffening angle, 18 kg/m	tonnes	129	$3,174.03	$410,085
Embedded perimeter angle, 18 kg/m	tonnes	42	$3,174.03	$132,674
Welding	m	18,392	$14.86	$273,305
Field Welding Premium	m	18,392	$40.06	$736,784
Misc. Structural Steel				
Alignment & pulling brackets etc., 5 tonnes per element	tonnes	190	$3,132.11	$595,101
Ballast Tanks (2/element)				
Steel support columns, 100 kg/m	tonnes	836	$2,709.04	$2,264,757
Timber lagging, 150 mm deep	m^2	13,543	$60.40	$818,009
Membrane liner	m^2	13,543	$27.84	$377,043
7 Internal Structural & Civil Finish Works - Zone 3				
Ballast				
Road ballast concrete, 2,500 psi, placed by chute	m3	17,813	$140.06	$2,494,819
Road ballast reinforcement: welded wire fabric 6 x 6 x #4, 2.8kg/m^2	m^2	39,900	$9.36	$373,464
Deduct in excess of 4.5 tonnes	tonne	107	-$41.01	-$4,388
Emergency corridor sand/cement mix for HVDC cables	m3	3,563	$140.06	$498,964
Precast Divider for Emergency Egress Corridor				
Panel fabrication, 8" thick, incuding reinformcement & lifting points	m^2	32,063	$196.98	$6,315,671
Panel setting, based upon max panel weight of 6 tons.	each	2,850	$285.70	$814,245
Seal and caulk panels	m	11,400	$5.48	$62,472
Sprayed fireproofing for precast panels	m^2	32,063	$20.77	$665,938
Roadway Surfacing				
Surface treatment, prepare & clean surface	km	5.7	$4,188.69	$23,876
Bituminous surface course, 75 mm thick	m3	2,993	$75.08	$224,677
8 Tunnel Transport & Placement				
Element Transport: tug rental etc.	each	120	$500,000.00	$60,000,000
Element placement: barge/pontoons,divers, survey etc.	each	120	$1,000,000.00	$120,000,000
Tunnel Closure				
Underwater joint completion	each	1	$2,500,000.00	$2,500,000
			Page Total	**$978,860,556**

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Strait of Belle Isle Crossing

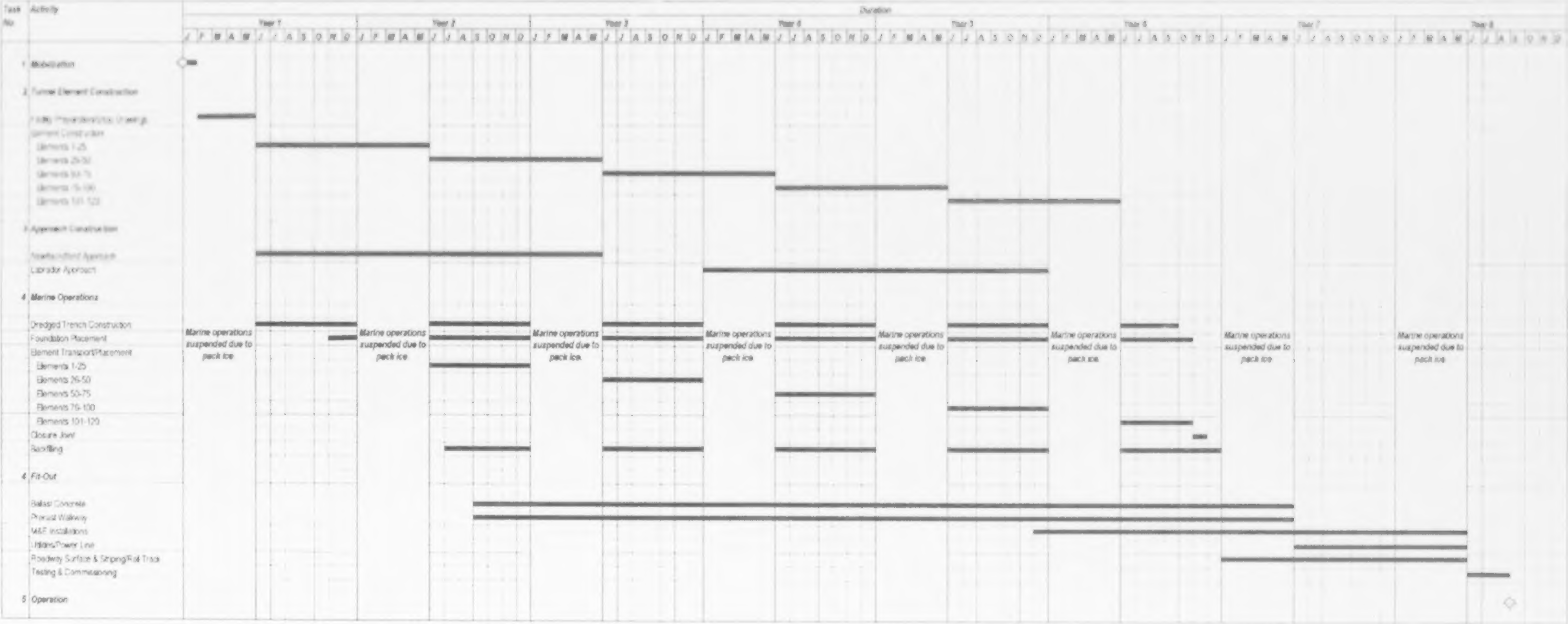
Preliminary Immersed Tube Tunnel Cost Estimate - Road Tunnel

Item	Unit	Quantity	Rate	Total
			Toal Brought Forward	$978,860,556
9 Marine Operation				
Dredging				
Mobilization/Demobilzation per season, 6 seasons, 2 vessels	each	24	$150,000.00	$3,600,000
Stage 1 bulk dredging of material	m3	5,255,299	$84.00	$441,445,116
Stage 2 fine tolerance dredging & additional trench cleaning	m3	788,295	$43.00	$33,896,685
Foundation and Backfill				
Bedded sand foundation	m3	263,385	$35.00	$9,218,475
Selected locking fill	m3	298,955	$35.00	$10.463,425
Backfill	m3	416,616	$35.00	$14,581,560
Rock armor protection	m3	664,488	$51.00	$33,888,888
Subtotal Structure Cost				**$1,525,954,705**
Tunnel MEP Systems	ls	10 % of structure cost		$152,595,470
Rail Systems	ls	15 % of structure cost		$228,893,206
Contingency on Tunnel Costs	ls	30% of subtotal structure cost		$457,786,411
"Soft" Costs				
Engineers design & construction supervision fee	ls	10% of construction cost		$236,522,979
Estimated Construction Cost				**$2,601,752,772**
Estimated Construction Cost per linear metre				**$144,542**

Appendix B
Construction Schedule

Strait Of Belle Isle Crossing

Preliminary Immersed Tube Tunnel Construction Schedule



APPENDIX D

DETAILED BREAKDOWN OF COST ESTIMATES

APPENDIX D (1)

BORED HIGHWAY TUNNEL COSTS

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Newfoundland Fixed Link Pre-feasibility - TBM Bored Highway Tunnel - Cost Summary

	BORED TUNNEL CONSTRUCTION COSTS	
ITEM	UNIT	MAIN TUNNEL
MOBILIZATION & DEMOBILIZATION	LS	8,000,000
TUNNELLING	LS	429,709,000
TUNNEL FINISHES	LS	203,170,000
NORTH APPROACH STRUCTURES	LS	5,920,000
SOUTH APPROACH STRUCTURES	LS	6,090,000
NORTH VENTILATION ADIT	LS	9,706,476
SOUTH VENTILATION ADIT	LS	21,978,156
ROAD FINISHES	LS	2,581,875
NORTH VEHICLE HOLDING AREA	LS	6,960,000
SOUTH VEHICLE HOLDING AREA	LS	4,260,000
TUNNEL DRAINAGE	LS	7,370,000
UTILITY DIVERSIONS	LS	1,000,000
MONITORING	LS	1,000,000
SUBTOTAL CIVIL		**$707,745,508**
CIVIL CONTINGENCIES		
CONTINGENCY	40%	$283,098,203
TOTAL CIVIL		**$990,843,711**
	M&E AND FINISHING WORK	
VENTILATION EQUIPMENT	LS	$6,000,000
VENTILATION BUILDINGS x 2	LS	$2,000,000
FIRE SUPPRESSION SYSTEM	LS	$4,000,000
CONTROL CENTRE	LS	$4,000,000
SIGNALLING	LS	$0
LIGHTING	LS	$2,936,553
CCTV SYSTEM	LS	$30,000
GAS DETECTION	LS	$890,000
SUBSTATION, GENERATORS, UPS	LS	$570,000
SUBTOTAL M&E AND FINISHING		**$20,426,553**
CONTINGENCIES	20%	$4,085,311
TOTAL M&E AND FINISHING		**$24,511,864**
TOTAL CIVIL, M&E AND FINISHING		**$1,015,355,575**
ALLOWANCES		
CONTRACTOR OH	15%	$152,303,336
CONTRACTOR PROFIT	15%	$152,303,336
CONSTRUCTION TOTAL		**$1,320,000,000**
	PRE-CONSTRUCTION AND SUPERVISION	
FEASIBILITY STUDY	LS	$11,000,000
ENVIRONMENTAL ASSESSMENT	LS	$4,000,000
DESIGN	5%	$66,000,000
CONSTRUCTION MANAGEMENT	10%	$132,000,000
OWNERS COSTS	2%	$26,400,000
PRE-CONSTRUCTION TOTAL		$239,400,000
GRAND TOTAL		**$1,559,400,000**

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Newfoundland Fixed Link Pre-feasibility - TBM Bored Highway Tunnel - Civil Costs

ITEM	UNIT	QTY	RATE	TOTAL
MOBILIZATION	LS	1.00	$8,000,000	$8,000,000
TUNNELLING				
- Set-up TBM	LS	1.00	$723,000	$723,000
- Tunnel drive	LS	1.00	$424,854,000	$424,854,000
- TBM maintenance	LS	1.00	$916,000	$916,000
- Remove TBM	LS	1.00	$398,000	$398,000
- Clean tunnel	LS	1.00	$2,818,000	$2,818,000
- Structural finishes	LS	1.00	$203,170,000	$203,170,000
NORTH APPROACH STRUCTURES				
- cut and cover approach	LS	1.00	$5,920,000	$5,920,000
SOUTH APPROACH STRUCTURES				
- cut and cover approach	LS	1.00	$6,090,000	$6,090,000
END VENTILATION ADITs				
- south adit	LS	1.00	$21,978,156	$21,978,156
- north adit	LS	1.00	$9,706,476	$9,706,476
DRAINAGE				
Drainage sumps and piping	LS	1.00	$7,370,000	$7,370,000
ROAD FINISHES				
- bored tunnel	m2	124,943.75	$20	$2,498,875
- north approach	m2	2,075.00	$20	$41,000
- south approach	m2	2,100.00	$20	$42,000
SUB-TOTAL				**$694,525,508**

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Tunnel Estimating Database

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Detailed Cost Estimate Report

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Project:	Newfoundland Fixed Link Pre-feasibility Study	**Project Number:**	213789
Estimate Description:	Set-up TBM	**Parent Estimate ID:**	1563
Tunnel Name:	Single Highway Bored	**Project Phase**	Conceptual
Construction Activity:	Erect TBM Only	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	May 31, 2004
Estimate Definition ID:	2631	**Tunnel Characteristics ID:**	842

Tunnel Characteristics

Finished Diameter: 11 m

Activity Details

Shift Arrangement 3 - 8 hour shifts x 7 days per week

Duration of Activity 4.5 Weeks

Total Number of Shifts 94.5

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor					
Pit boss	52.29	$/hr	756.00	1.00	39,531
Tunnel miner	48.89	$/hr	756.00	2.00	73,922
Shaft bottom	48.44	$/hr	756.00	3.00	109,862
Tunnel fitter	49.34	$/hr	756.00	1.00	37,301
Tunnel electrician	49.34	$/hr	756.00	1.00	37,301
Shaft top	47.99	$/hr	756.00	1.00	36,280
Crane operator	49.34	$/hr	756.00	2.00	74,602
Surface laborer	47.99	$/hr	756.00	1.00	36,280
Equipment laborer	48.44	$/hr	756.00	1.00	36,621
				13.00	$481,701
Plant					
Loco	5,000.00	$/wk	4.50	1.00	22,500
Muck cars & grout cars	1,900.00	$/wk	4.50	6.00	51,300
Flat cars	310.00	$/wk	4.50	2.00	2,790
Transformers & switchgear - LV	750.00	$/wk	4.50	1.00	3,375
Small tools	2,600.00	$/wk	4.50	1.00	11,700
Shaft crane	9,000.00	$/wk	4.50	1.00	40,500
Erection crane	10,000.00	$/wk	4.50	1.00	45,000
Compressors	950.00	$/wk	4.50	1.00	4,275
Generators	2,000.00	$/wk	4.50	1.00	9,000
Transformers & switchgear - HV	5,200.00	$/wk	4.50	1.00	23,400
Loaders	2,300.00	$/wk	4.50	1.00	10,350
					$224,190
Consumables					
Electrical power	0.00	$/kwh	756.00	300.00	0
Gas oil	0.00	$/L	0.00	1.00	0

Estimate Definition ID: 2631

Estimated by: ____________

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Checked by: ____________

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Lubrication materials	0.00	$/wk	4.50	1.00	0
Filters etc.	0.00	$/wk	4.50	1.00	0
Hydraulic oil	0.00	$/L	0.00	1.00	0
Other consumables	0.00	$/wk	4.50	1.00	0
					$0
Materials					
Temporary materials	2,000.00	$/wk	4.50	1.00	9,000
Thrust frame	5,000.00	$/wk	4.50	1.00	22,500
					$31,500
			Total Estimated Cost:		$737,391

Estimate Definition ID: 2631

Estimated by: ____________

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Checked by: ____________

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Tunnel Estimating Database

Detailed Cost Estimate Report

Version 2.6

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Project:	Newfoundland Fixed Link Pre-feasibility Study	**Project Number:**	213789
Estimate Description:	Tunnel drive	**Parent Estimate ID:**	1559
Tunnel Name:	Single Highway Bored	**Project Phase:**	Conceptual
Construction Activity:	TBM Tunneling	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	May 31, 2004
Estimate Definition ID:	2632	**Tunnel Characteristics ID:**	842

Tunnel Characteristics

Tunnel Length:	19,991	m
Finished Diameter:	11	m
Initial Support Type:	Pre-cast concrete segments	
Initial Support Thickness:	0	m
Final Lining Thickness:	0.55	m
Grout Thickness:	0.125	m

Theoretical Excavation Volumes

Total Neat Excavation:	2,394,738	Cubic Metres
Initial Lining Volume:	0	Cubic Metres
Final Lining Volume:	398,959	Cubic Metres
Theoretical Grout Volume:	95,972	Cubic Metres

Normal Excavation/Support Cycle

Excavation Cycle Length:	1.5	Metres
Excavate:	28	Minutes
Erect Support:	36	Minutes
Extend Services:	0	Minutes
Total Cycle Time:	64	Minutes

Difficult Excavation/Support Cycle

Length of Difficult Excavation:	1400	Metres
Excavate:	92	Minutes
Erect Support:	74	Minutes
Extend Services:	0	Minutes
Total Cycle Time:	166	Minutes

Reduction Factors

Machine availability:	80	%
Back up efficiency:	55	%
Planned maintenance:	5	%
Learning curve efficiency:	40	%
Learning curve duration time:	8	Weeks

Learning Curve Rate:	5.6	m/day
Experienced Advance Rate:	14.1	m/day
Difficult Advance Rate:	5.4	m/day

TBM Skidding Through Excavation

Duration of skidding:	0	Weeks
Length of skidding:	0	Metres

Advance Rate and Shift Details

Shift Arrangement:	3 - 8 hour shifts x 7 days per week	
Avg. Drive Advance per Shift:	4.14	Metres
Avg. Drive Advance per Day:	12	Metres
Avg. Drive Advance per Week:	87	Metres
Duration of Tunneling (Incl. Skid):	229.83	Weeks
Total number of shifts (Incl. Skid):	4,827	

	Metres	Days
Learning Curve Drive:	316	56
Experienced Drive:	18,275	1,295
Difficult Drive:	1,400	257
Skidding Portion:	0	0

Estimate Definition ID: 2632

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Estimated by: ____________________

Checked by: ____________________

	Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor						
	Pit boss	52.29	$/hr	38,615.00	1.00	2,019,178
	Working foreman	52.29	$/hr	38,615.00	2.00	4,038,357
	Tunnel miner	48.89	$/hr	38,615.00	3.00	5,663,662
	Tunnel laborer	48.44	$/hr	38,615.00	4.00	7,482,042
	Loco driver	49.34	$/hr	38,615.00	4.00	7,621,056
	Shaft bottom	48.44	$/hr	38,615.00	1.00	1,870,511
	TBM operator	49.34	$/hr	38,615.00	1.00	1,905,264
	Tunnel fitter	49.34	$/hr	38,615.00	1.00	1,905,264
	Tunnel electrician	49.34	$/hr	38,615.00	1.00	1,905,264
	Shaft top	47.99	$/hr	38,615.00	2.00	3,706,268
	Crane operator	49.34	$/hr	38,615.00	1.00	1,905,264
	Surface laborer	47.99	$/hr	38,615.00	4.00	7,412,535
	Equipment laborer	48.44	$/hr	38,615.00	4.00	7,482,042
					29.00	$54,916,708
Plant						
	TBM	300,000.00	$/m2	119.79	0.80	28,749,600
	TBM backup	1,430,000.00	$/Nr	1.00	1.00	1,430,000
	Loco	5,000.00	$/wk	229.83	4.00	4,596,600
	Muck cars & grout cars	1,900.00	$/wk	229.83	56.00	24,453,912
	Flat cars	310.00	$/wk	229.83	8.00	569,978
	Manriders	310.00	$/wk	229.83	2.00	142,495
	Track	130.00	$/m	19,991.00	1.00	2,598,830
	Air pipe	30.00	$/m	19,991.00	1.00	599,730
	Water pipe	25.00	$/m	19,991.00	1.00	499,775
	Pump main	50.00	$/m	19,991.00	1.00	999,550
	Cabling	80.00	$/m	19,991.00	1.00	1,599,280
	Lighting	30.00	$/m	19,991.00	1.00	599,730
	Vent ducting	30.00	$/m	19,991.00	1.00	599,730
	Grout mixers	7,100.00	$/wk	229.83	1.00	1,631,793
	Grout pumps	3,400.00	$/wk	229.83	1.00	781,422
	Grout hoses & pipes	196.00	$/wk	229.83	2.00	90,093
	Transformers & switchgear - LV	750.00	$/wk	229.83	2.00	344,745
	Small tools	2,600.00	$/wk	229.83	1.00	597,558
	Shaft crane	9,000.00	$/wk	229.83	1.00	2,068,470
	Compressors	950.00	$/wk	229.83	1.00	218,339
	Low pressure C/A system	3,800.00	$/wk	229.83	1.00	873,354
	Pipework and controls	655.00	$/wk	229.83	2.00	301,077
	Generators	2,000.00	$/wk	229.83	1.00	459,660
	Transformers & switchgear - HV	5,200.00	$/wk	229.83	1.00	1,195,116
	Surface fans	800.00	$/wk	229.83	2.00	367,728
	Loaders	2,300.00	$/wk	229.83	2.00	1,057,218
	Other surface plant	2,600.00	$/wk	229.83	1.00	597,558

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Tunnel C/A system	40,000.00	$/wk	229.83	1.00	9,193,200
					$87,216,541
Consumables					
Electrical power	0.10	$/kwh	38,615.00	3,000.00	11,584,500
Gas oil	0.45	$/L	48,000.00	1.00	21,600
Lubrication materials	90.00	$/wk	229.83	1.00	20,685
TBM spares, cutters	250.00	$/m	19,991.00	1.00	4,997,750
Filters etc.	300.00	$/wk	229.83	1.00	68,949
Hydraulic oil	0.90	$/L	32,000.00	1.00	28,800
Other consumables	160.00	$/wk	229.83	1.00	36,773
Tail seal grease	100.00	$/m	19,991.00	1.00	1,999,100
					$18,758,157
Materials					
Concrete lining rings	13,211.47	$/Nr	13,328.00	1.00	176,082,407
Gaskets	110.00	$/m	19,991.00	1.00	2,199,010
Bolts	12.00	$/Nr	1,765.00	30.00	635,400
Grout	145.00	$/m3	95,972.00	1.00	13,915,940
Grout plugs	0.50	$/Nr	1,765.00	7.00	6,178
Packers	10.00	$/Nr	3,633.00	12.00	435,960
Temporary materials	2,250.00	$/wk	229.83	1.00	517,118
Other materials	0.00	$/t	0.00	1.00	0
					$193,792,012
Subcontracts					
Soil disposal	20.00	$/m3	2,394,738.00	1.50	71,842,140
					$71,842,140

Total Estimated Cost:	$426,525,558
Total Estimated Cost per Metre:	$21,336
Total Estimated Cost per Week:	$1,855,833
Total Estimated Cost per Shift:	$88,364

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Tunnel Estimating Database

Version 2.6

Detailed Cost Estimate Report

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Project:	Newfoundland Fixed Link Pre-feasibility Study	**Project Number:**	213789
Estimate Description:	Maintain TBM	**Parent Estimate ID:**	1561
Tunnel Name:	Single Highway Bored	**Project Phase:**	Conceptual
Construction Activity:	TBM Maintenance	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	May 31, 2004
Estimate Definition ID:	2633	**Tunnel Characteristics ID:**	842

Tunnel Characteristics

Finished Diameter: 11 m

Activity Details

Shift Arrangement 1 - 6 hour shifts x 1 days per week

Duration of Activity 229 Weeks

Total Number of Shifts 229

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor					
Working foreman	52.29	$/hr	1,374.00	1.50	107,770
Loco driver	49.34	$/hr	1,374.00	1.50	101,690
Shaft bottom	48.44	$/hr	1,374.00	1.50	99,835
TBM operator	49.34	$/hr	1,374.00	1.50	101,690
Tunnel fitter	49.34	$/hr	1,374.00	1.50	101,690
Tunnel electrician	49.34	$/hr	1,374.00	1.50	101,690
Shaft top	47.99	$/hr	1,374.00	1.50	98,907
Surface laborer	47.99	$/hr	1,374.00	1.50	98,907
				12.00	$812,178
Consumables					
Electrical power	0.10	$/kwh	1,374.00	600.00	82,440
Gas oil	0.45	$/L	0.00	1.00	0
Other consumables	0.00	$/wk	229.00	1.00	0
					$82,440
Materials					
Temporary materials	200.00	$/wk	229.00	1.00	45,800
Other materials	0.00	$/t	0.00	1.00	0
					$45,800

Total Estimated Cost: $940,418

Estimate Definition ID: 2633

Estimated by: ____________________

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Project:	Newfoundland Fixed Link Pre-feasibility Study	**Project Number:**	213789
Estimate Description:	Clean tunnel	**Parent Estimate ID:**	1562
Tunnel Name:	Single Highway Bored	**Project Phase:**	Conceptual
Construction Activity:	Tunnel Clean Up	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	May 21, 2004
Estimate Definition ID:	2634	**Tunnel Characteristics ID:**	842

Tunnel Characteristics

Tunnel Length:	19,991	m	
Finished Diameter:	11	m	(Circular Tunnels)
Excavated Cross Section:	0	m2	(Non-circular Tunnels)
Excavated Perimeter:	0	m	(Non-circular Tunnels)

Productivity Cycle

Section Length	30	Metres
Vent Line Removal Time	120	Minutes
Track Removal Time	60	Minutes
Temp Lighting Removal Time	60	Minutes
Clean Up Time	120	Minutes
Total Cycle Time	360	Minutes

Reduction Factors

Learning Curve Efficiency:	50	%
Back Up Efficiency:	80	%
Learning Curve Duration:	1	Weeks

Shift Details

Shift Arrangement:	3 - 8 hour shifts x 7 days per week	
Avg. Advance per Shift:	31.45	Metres
Avg. Advance per Week:	661	Metres
Total number of hours:	5,086	

Clean Up Productivity Data

	Average Advance		Drive Length		Drive Duration					
Learning Curve Portion:	48.0	m/day	336	Metres	21	Shifts	7	Days	1.00	Weeks
Experienced Drive Portion:	96.0	m/day	19,655	Metres	614	Shifts	205	Days	29.25	Weeks
Total:	94.4	m/day	19,991	Metres	636	Shifts	212	Days	30.25	Weeks

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor					
Tunnel laborer	48.44	$/hr	5,086.00	6.00	1,478,195
Shaft bottom	48.44	$/hr	5,086.00	1.00	246,366
Shaft top	47.99	$/hr	5,086.00	1.00	244,077
Crane operator	49.34	$/hr	5,086.00	1.00	250,943
				9.00	$2,219,581
Plant					
Transformers & switchgear - LV	750.00	$/wk	30.25	1.00	22,688

Estimated by: ____________

Checked by: ____________

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Man hoists	2,600.00	$/wk	30.25	1.00	78,650
Shaft crane	9,000.00	$/wk	30.25	1.00	272,250
Compressors	950.00	$/wk	30.25	1.00	28,738
Loaders	2,260.00	$/wk	30.25	1.00	68,365
Other surface plant	2,600.00	$/wk	30.25	1.00	78,650
Bobcat	500.00	$/wk	30.25	1.00	15,125
					$564,465

Consumables

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Electrical power	0.10	$/kwh	5,086.00	200.00	101,720
					$101,720

Total Estimated Cost:	$2,885,766
Total Estimated Cost per Metre:	$144
Total Estimated Cost per Week:	$95,402
Total Estimated Cost per Shift:	$4,539

Estimate Definition ID: 2634

Estimated by: ____________________

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Tunnel Estimating Database

Detailed Cost Estimate Report

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Project:	Newfoundland Fixed Link Pre-feasibility Study	**Project Number:**	213789
Estimate Description:	Remove TBM	**Parent Estimate ID:**	1564
Tunnel Name:	Single Highway Bored	**Project Phase:**	Preliminary
Construction Activity:	TBM Removal	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	May 21, 2004
Estimate Definition ID:	2635	**Tunnel Characteristics ID:**	842

Tunnel Characteristics

Finished Diameter: 11 m

Activity Details

Shift Arrangement	3 - 8 hour shifts x 7 days per week
Duration of Activity	2.2 Weeks
Total Number of Shifts	46.2

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor					
Pit boss	52.29	$/hr	370.00	1.00	19,347
Tunnel miner	48.89	$/hr	370.00	3.00	54,268
Shaft bottom	48.44	$/hr	370.00	2.00	35,846
Tunnel fitter	49.34	$/hr	370.00	1.00	18,256
Tunnel electrician	49.34	$/hr	370.00	1.00	18,256
Shaft top	47.99	$/hr	370.00	2.00	35,513
Crane operator	49.34	$/hr	370.00	2.00	36,512
Surface laborer	47.99	$/hr	370.00	2.00	35,513
Equipment laborer	48.44	$/hr	370.00	1.00	17,923
				15.00	$271,432
Plant					
Loco	5,000.00	$/wk	2.20	1.00	11,000
Muck cars & grout cars	1,900.00	$/wk	2.20	6.00	25,080
Flat cars	310.00	$/wk	2.20	4.00	2,728
Manriders	310.00	$/wk	2.20	1.00	682
Booster fans	800.00	$/wk	2.20	1.00	1,760
Transformers & switchgear - LV	750.00	$/wk	2.20	1.00	1,650
Other plant	1,400.00	$/wk	2.20	1.00	3,080
Man hoists	2,000.00	$/wk	2.20	1.00	4,400
Shaft crane	9,000.00	$/wk	2.20	1.00	19,800
50T Crane	3,000.00	$/wk	2.20	1.00	6,600
TBM Crane	15,000.00	$/wk	2.20	1.00	33,000
Compressors	950.00	$/wk	2.20	1.00	2,090
Transformers & switchgear - HV	5,200.00	$/wk	2.20	1.00	11,440
Surface fans	800.00	$/wk	2.20	1.00	1,760
					$125,070

Estimate Definition ID: 2635

Estimated by: ____________________

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Checked by: ____________________

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Consumables					
Electrical power	0.00	$/kwh	370.00	600.00	0
Gas oil	0.40	$/L	15.00	1,000.00	6,000
Lubrication materials	0.00	$/wk	2.20	1.00	0
Filters etc.	0.00	$/wk	2.20	1.00	0
Hydraulic oil	0.00	$/L	0.00	1.00	0
Other consumables	500.00	$/wk	2.20	1.00	1,100
					$7,100
Materials					
Temporary materials	500.00	$/wk	2.20	1.00	1,100
Thrust frame	0.00	$/wk	2.20	1.00	0
					$1,100
General Supplies					
Small tools	700.00	$/wk	2.20	1.00	1,540
					$1,540
			Total Estimated Cost:		$406,242

Estimate Definition ID: 2635

Estimated by: ____________________

Checked by: ____________________

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: North Approach
Option: Bored Highway Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient	0.4	%	+ sloping same way as track/road - sloping against track/road
Track/Road Gradient	6	%	
Ground elevation at portal	100	m	
Bottom of slab elevation at portal	81.6	m	

Total length= 328.5714 m

Total Cost=$ 5.9 M

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Highway Tunnel

UNIT RATES

Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: North Approach
Option: Bored Highway Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient	0.4	%	+ sloping same way as track/road - sloping against track/road
Track/Road Gradient	6	%	
Ground elevation at portal	100	m	
Bottom of slab elevation at portal	81.6	m	
Total length=	328.5714	m	
Total Cost=$	5.9	M	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Highway Tunnel

UNIT RATES

Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

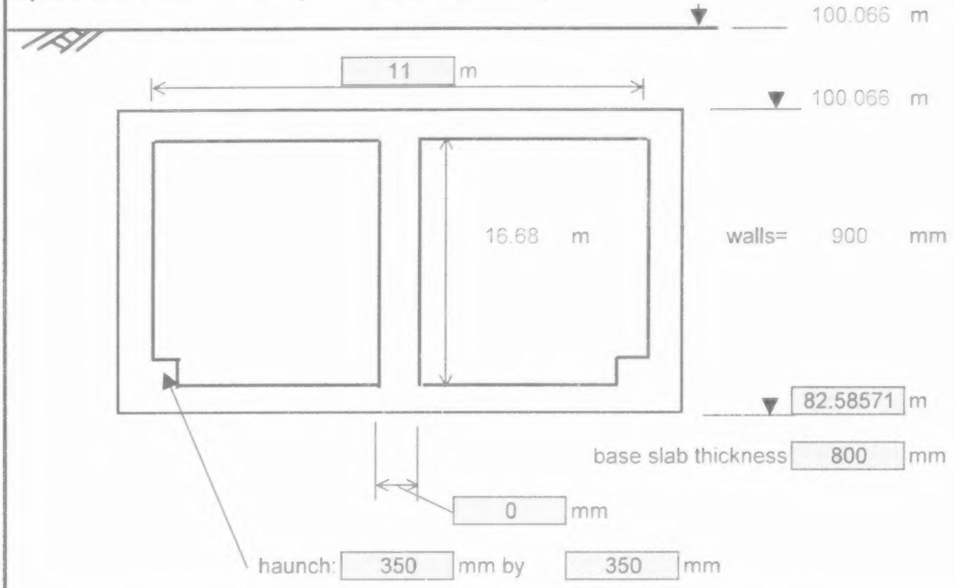
Newfoundland Fixed Link Pre-feasibility Study
North Approach
Bored Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 32.85714 m

Section 1

Input cross-section details (cut and cover solution)



100.066 m
11 m
100.066 m
16.68 m
walls= 900 mm
82.58571 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

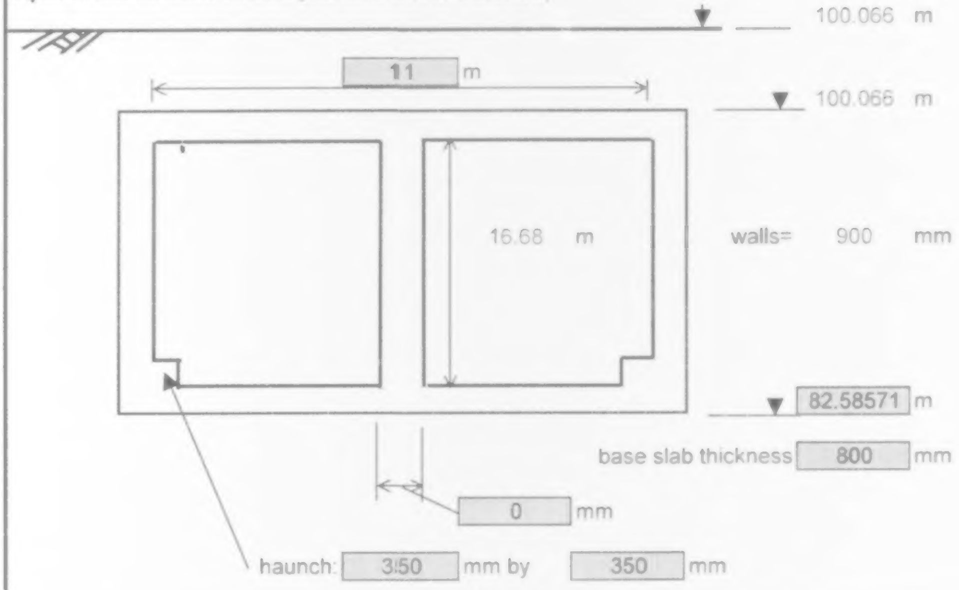
Calculated Quantities

excavation=	7351.6	m3	
concrete=	1331.01	m3	
rebar=	159.7	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1096.114	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	1148.7	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	420.5714	m2	

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
North Approach	**Calculations by:** ANW
Bored Highway Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 32.85714 m **Section 1**

Input cross-section details (cut and cover solution)


100.066 m
11 m
100.066 m
16.68 m
walls= 900 mm
82.58571 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	7351.6	m3
concrete=	1331.01	m3
rebar=	159.7	tonnes (assume 0.12t/m3 of concrete)
formwork/falsework=	1096.114	m2
SP&L<=4.6m deep	0.0	m2
4.6<SP&L<=6.7m deep	0.0	m2
6.7<SP&L<=10.6m deep	0.0	m2
10.6<SP&L<=13.7m deep	0.0	m2
13.7<SP&L<=16.8m deep	0.0	m2
16.8<SP&L<=20.0m deep	1148.7	m2
20<SP&L<=25m deep	0.0	m2
backfill=	0	m3
surface reinstatement=	420.5714	m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	7351.6	60	441095.3
concrete	m3	1331.01	190.0	252891.9
rebar	tonnes	159.7	1600	255553.9
formwork/falsework	m2	1096.114	140	153456
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	1148.7	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	420.5714	30	12617.14
			Total	1115614

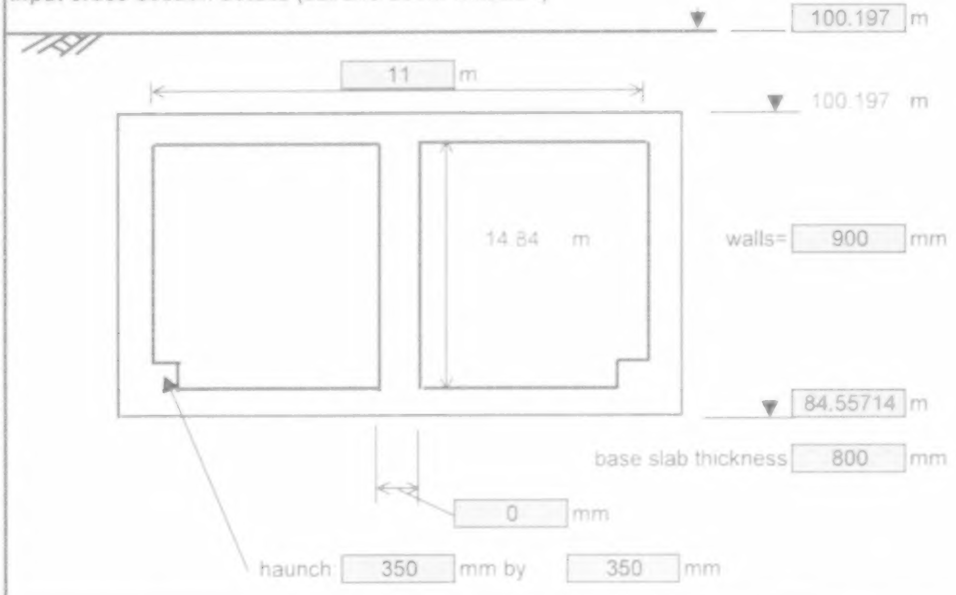
Newfoundland Fixed Link Pre-feasibility Study
North Approach
Bored Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 32.85714 m

Section 2

Input cross-section details (cut and cover solution)


100.197 m
11 m
100.197 m
14.84 m
walls= 900 mm
84.55714 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

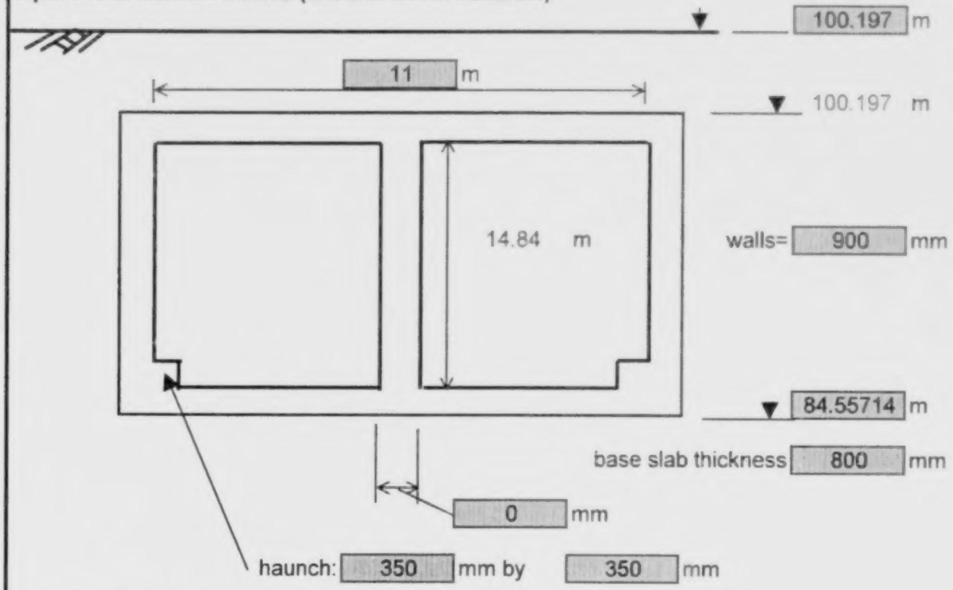
Calculated Quantities

excavation=	6577.7	m3	
concrete=	1222.187	m3	
rebar=	146.7	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	975.2	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	1027.8	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	420.5714	m2	

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
North Approach	**Calculations by:** ANW
Bored Highway Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 32.85714 m **Section** 2

Input cross-section details (cut and cover solution)


100.197 m
11 m
100.197 m
14.84 m
walls= 900 mm
84.55714 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	6577.7	m3	
concrete=	1222.187	m3	
rebar=	146.7	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	975.2	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	1027.8	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	420.5714	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 2 of 2**

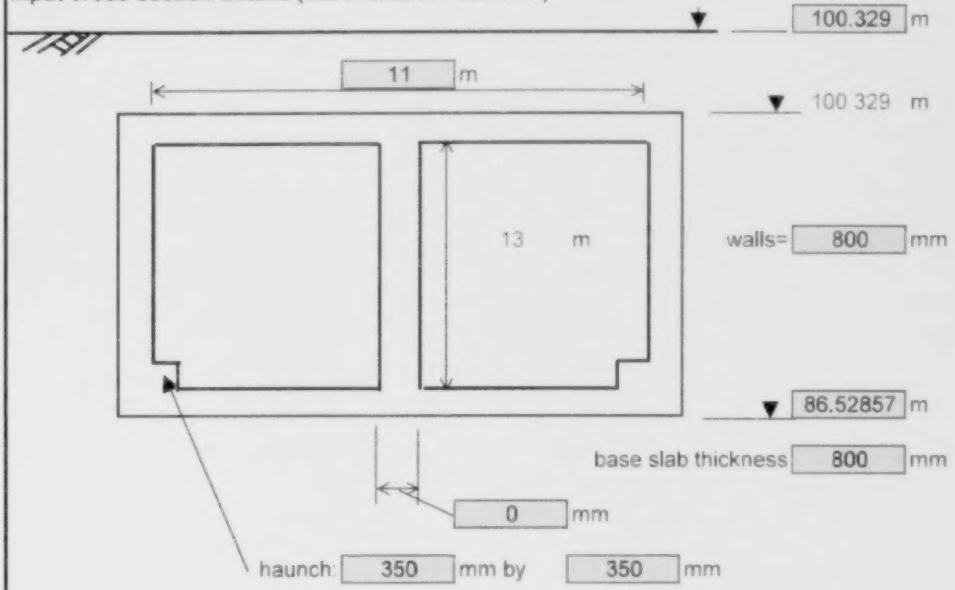
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	6577.7	60	394664.2
concrete	m3	1222.187	190.0	232215.6
rebar	tonnes	146.7	1600	234659.9
formwork/falsework	m2	975.2	140	136528
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	1027.8	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	420.5714	30	12617.14
			Total	1010685

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 32.85714 m **Section** 3

Input cross-section details (cut and cover solution)


100.329 m
11 m
100.329 m
13 m
walls= 800 mm
86.52857 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

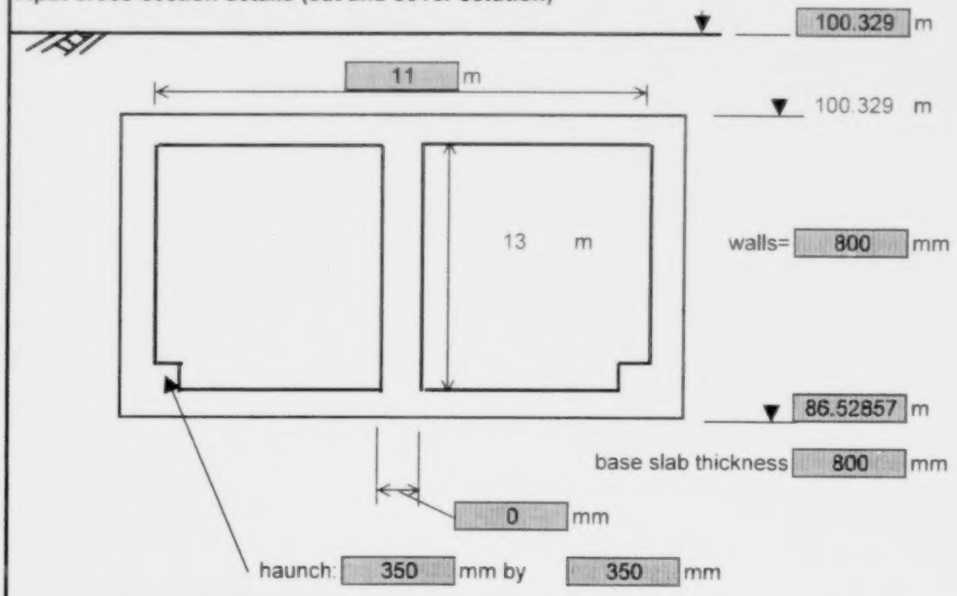
Calculated Quantities

excavation=	5713.2	m3	
concrete=	1022.679	m3	
rebar=	122.7	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	854.2857	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	906.9	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	414	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 32.85714 m **Section 3**

Input cross-section details (cut and cover solution)


100.329 m
11 m
100.329 m
13 m
walls= 800 mm
86.52857 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	5713.2	m3	
concrete=	1022.679	m3	
rebar=	122.7	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	854.2857	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	906.9	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	414	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 2 of 2**

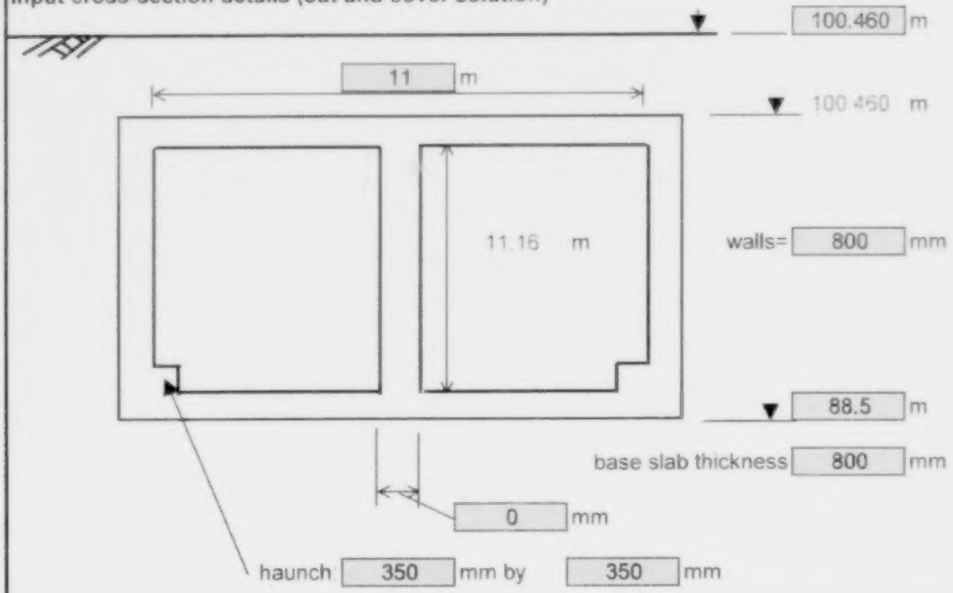
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	5713.2	60	342792
concrete	m3	1022.679	190.0	194308.9
rebar	tonnes	122.7	1600	196354.3
formwork/falsework	m2	854.2857	140	119600
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	906.9	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	414	30	12420
			Total	865475.2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 32.85714 m **Section** **4**

Input cross-section details (cut and cover solution)


100.460 m
11 m
100.460 m
11.16 m
walls= 800 mm
88.5 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

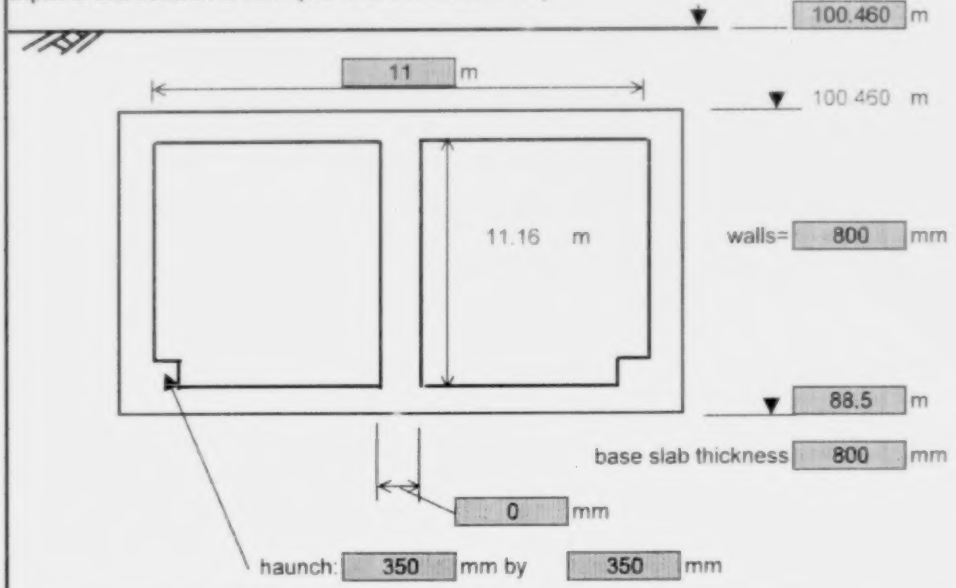
excavation=	4951.4	m3	
concrete=	925.9471	m3	
rebar=	111.1	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	733.3714	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	785.9	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	414	m2	

Newfoundland Fixed Link Pre-feasibility Study
North Approach
Bored Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 32.85714 m **Section** 4

Input cross-section details (cut and cover solution)


100.460 m
11 m
100.460 m
11.16 m
walls= 800 mm
88.5 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	4951.4	m3	
concrete=	925.9471	m3	
rebar=	111.1	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	733.3714	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	785.9	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	414	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 2 of 2**

Calculated costs

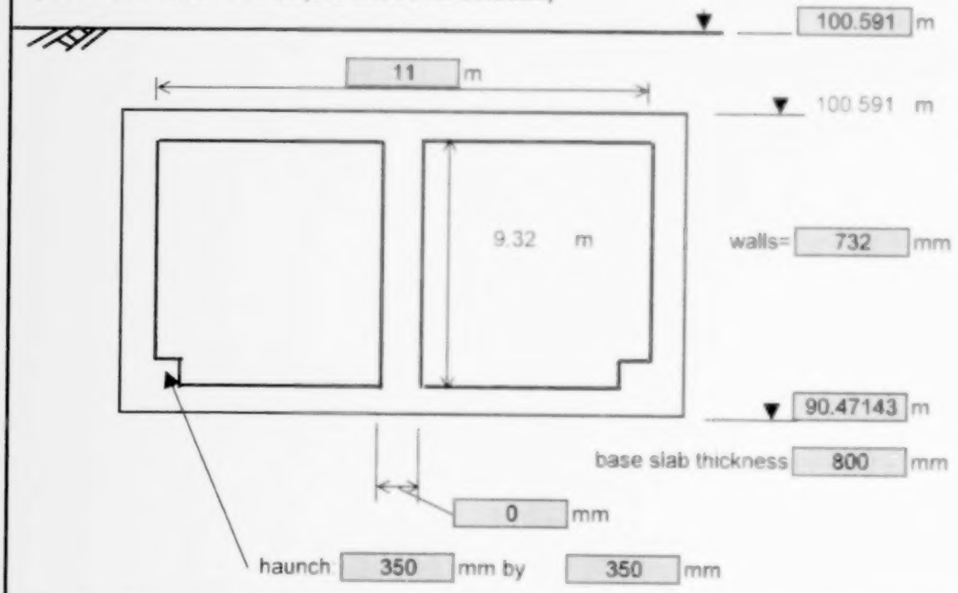
Item	Unit	Quantity	Rate	Cost
excavation	m3	4951.4	60	297086.4
concrete	m3	925.9471	190.0	175930
rebar	tonnes	111.1	1600	177781.9
formwork/falsework	m2	733.3714	140	102672
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	785.9	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	414	30	12420
			Total	765890.2

Newfoundland Fixed Link Pre-feasibility Study
North Approach
Bored Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 32.85714 m
Section 5

Input cross-section details (cut and cover solution)


100.591 m
11 m
100.591 m
9.32 m
walls= 732 mm
90.47143 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

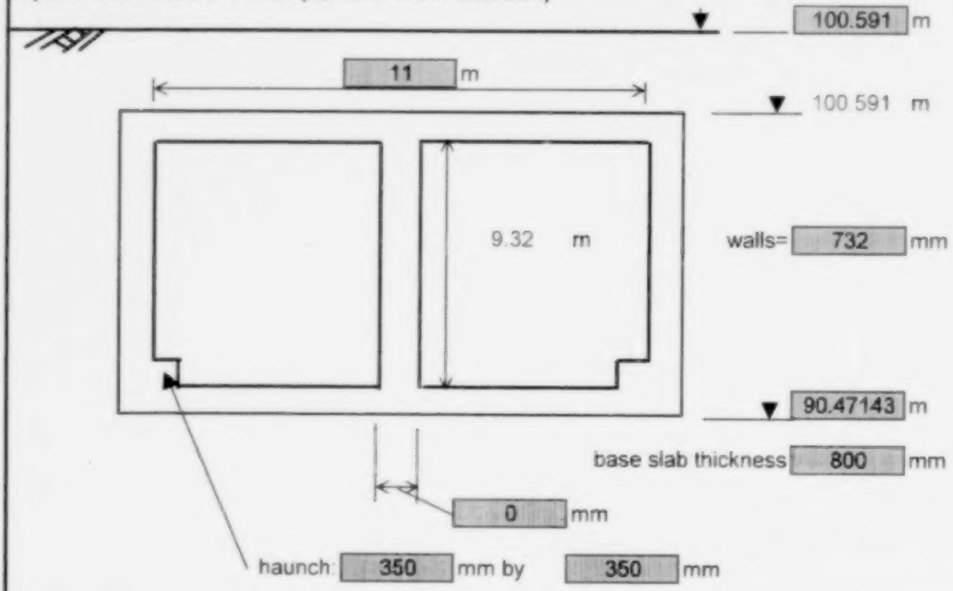
excavation=	4144.5	m3	
concrete=	783.9938	m3	
rebar=	94.1	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	612.4571	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	665.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	409.5314	m2	

Newfoundland Fixed Link Pre-feasibility Study
North Approach
Bored Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 32.85714 m
Section 5

Input cross-section details (cut and cover solution)



100.591 m
11 m
100.591 m
9.32 m
walls= 732 mm
90.47143 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	4144.5	m3	
concrete=	783.9938	m3	
rebar=	94.1	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	612.4571	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	665.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	409.5314	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	4144.5	60	248667.5
concrete	m3	783.9938	190.0	148958.8
rebar	tonnes	94.1	1600	150526.8
formwork/falsework	m2	612.4571	140	85744
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	665.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	409.5314	30	12285.94
			Total	646183

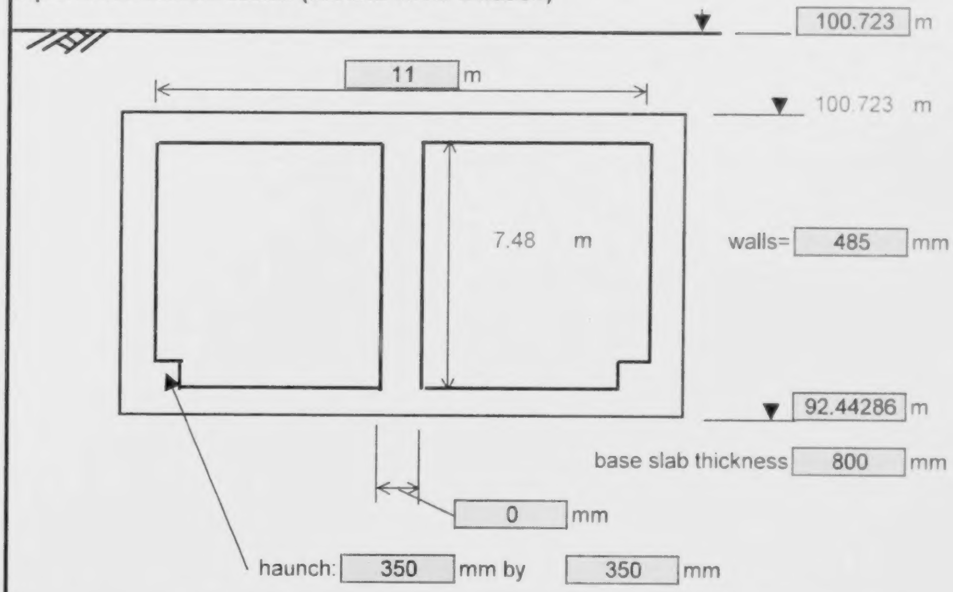
Newfoundland Fixed Link Pre-feasibility Study
North Approach
Bored Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 32.85714 m

Section 6

Input cross-section details (cut and cover solution)



walls= 485 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

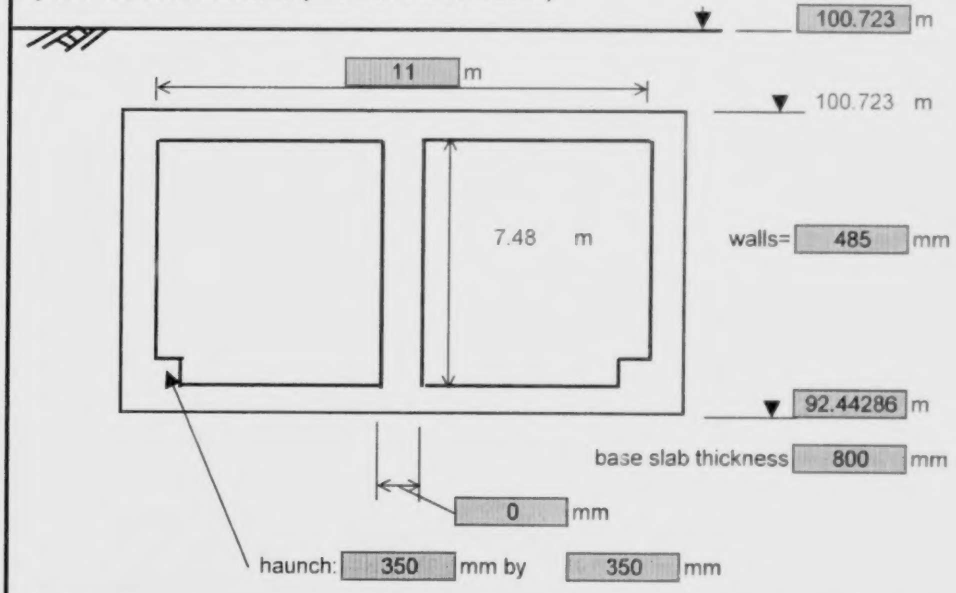
Calculated Quantities

excavation=	3256.5	m3	
concrete=	561.0883	m3	
rebar=	67.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	491.5429	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	544.1	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	393.3	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 32.85714 m **Section 6**

Input cross-section details (cut and cover solution)


100.723 m
11 m
100.723 m
7.48 m
walls= 485 mm
92.44286 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	3256.5	m3	
concrete=	561.0883	m3	
rebar=	67.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	491.5429	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	544.1	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	393.3	m2	

Newfoundland Fixed Link Pre-feasibility Study
North Approach
Bored Highway Tunnel

Date: 8-Jun-04
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Page 2 of 2

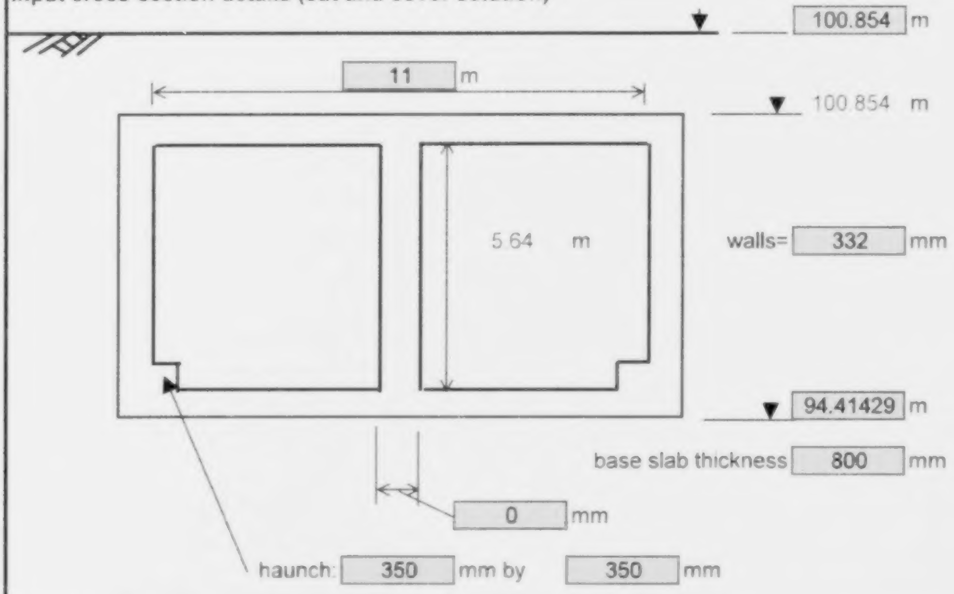
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	3256.5	60	195391.4
concrete	m3	561.0883	190.0	106606.8
rebar	tonnes	67.3	1600	107729
formwork/falsework	m2	491.5429	140	68816
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	544.1	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	393.3	30	11799
			Total	490342.2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 32.85714 m **Section** 7

Input cross-section details (cut and cover solution)


100.854 m
11 m
100.854 m
5.64 m
walls= 332 mm
94.41429 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

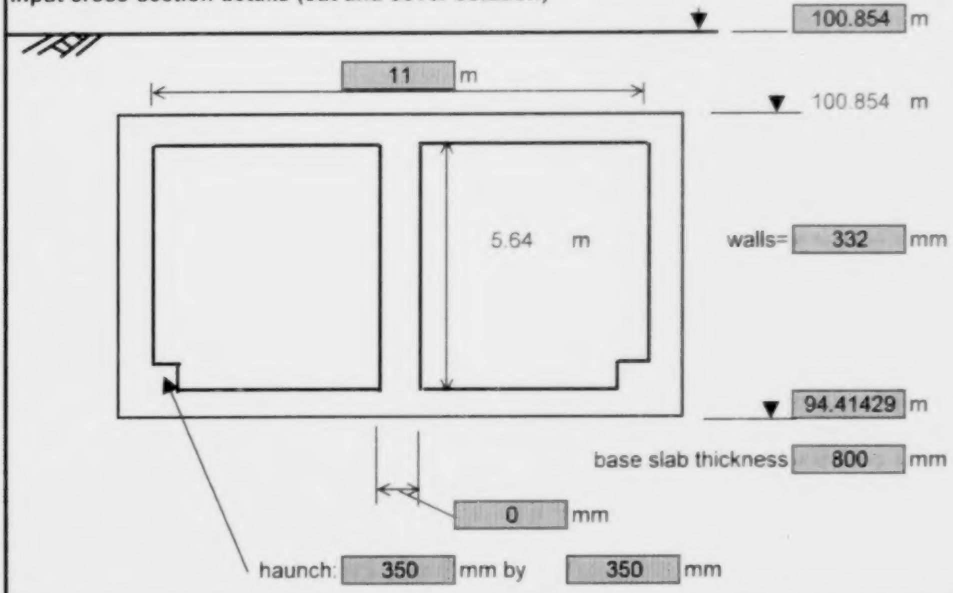
excavation=	2468.1	m3	
concrete=	437.6953	m3	
rebar=	52.5	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	370.6286	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	423.2	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	383.2457	m2	

Newfoundland Fixed Link Pre-feasibility Study
North Approach
Bored Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 32.85714 m **Section** 7

Input cross-section details (cut and cover solution)


100.854 m
11 m
100.854 m
5.64 m
walls= 332 mm
94.41429 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	2468.1	m3	
concrete=	437.6953	m3	
rebar=	52.5	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	370.6286	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	423.2	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	383.2457	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	2468.1	60	148086.1
concrete	m3	437.6953	190.0	83162.1
rebar	tonnes	52.5	1600	84037.49
formwork/falsework	m2	370.6286	140	51888
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	423.2	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	383.2457	30	11497.37
			Total	378671.1

Newfoundland Fixed Link Pre-feasibility Study
North Approach
Bored Highway Tunnel

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Calculations by: ANW
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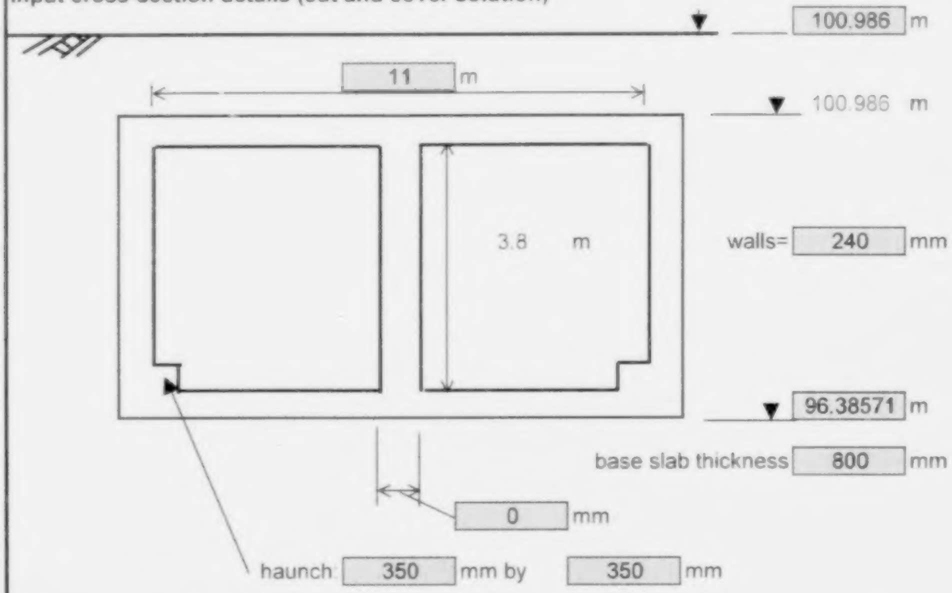
Section Cut and Cover
Length of section: 32.85714 m

Section 8

Input cross-section details (cut and cover solution)



100.986 m
11 m
100.986 m
3.8 m
walls= 240 mm
96.38571 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

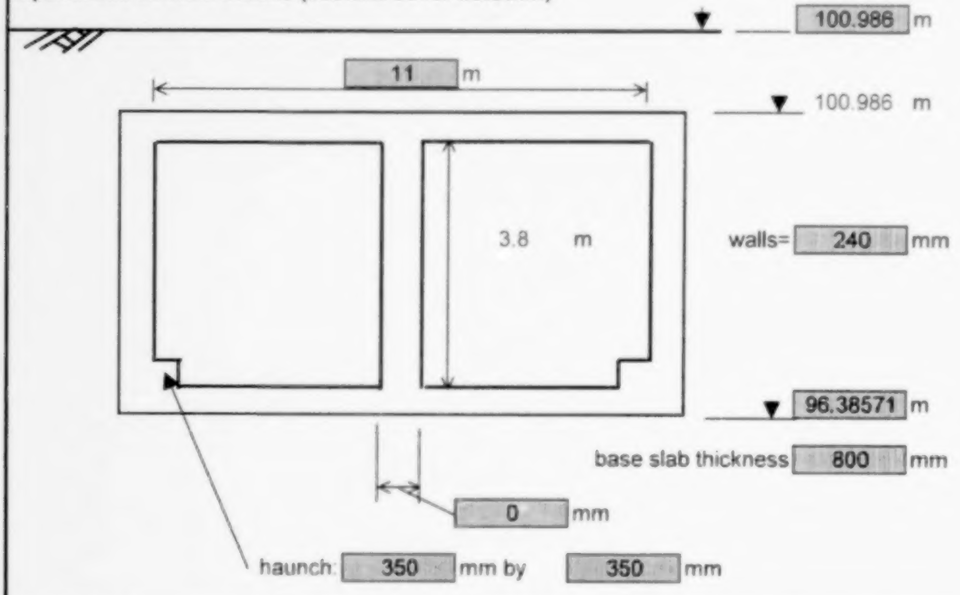
excavation=	1735.1	m3	
concrete=	369.7414	m3	
rebar=	44.4	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	249.7143	m2	
SP&L<=4.6m deep	302.3	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	377.2	m2	

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
North Approach	**Calculations by:** ANW
Bored Highway Tunnel	**Page 1 of 2**

Section Cut and Cover

Length of section: 32.85714 m **Section 8**

Input cross-section details (cut and cover solution)


100.986 m
11 m
100.986 m
3.8 m
walls= 240 mm
96.38571 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	1735.1	m3	
concrete=	369.7414	m3	
rebar=	44.4	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	249.7143	m2	
SP&L<=4.6m deep	302.3	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	377.2	m2	

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
North Approach	**Calculations by:** ANW
Bored Highway Tunnel	**Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	1735.1	60	104107.2
concrete	m3	369.7414	190.0	70250.87
rebar	tonnes	44.4	1600	70990.35
formwork/falsework	m2	249.7143	140	34960
SP&L<=4.6m deep	m2	302.3	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	377.2	30	11316
			Total	291624.4

Newfoundland Fixed Link Pre-feasibility Study
North Approach
Bored Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
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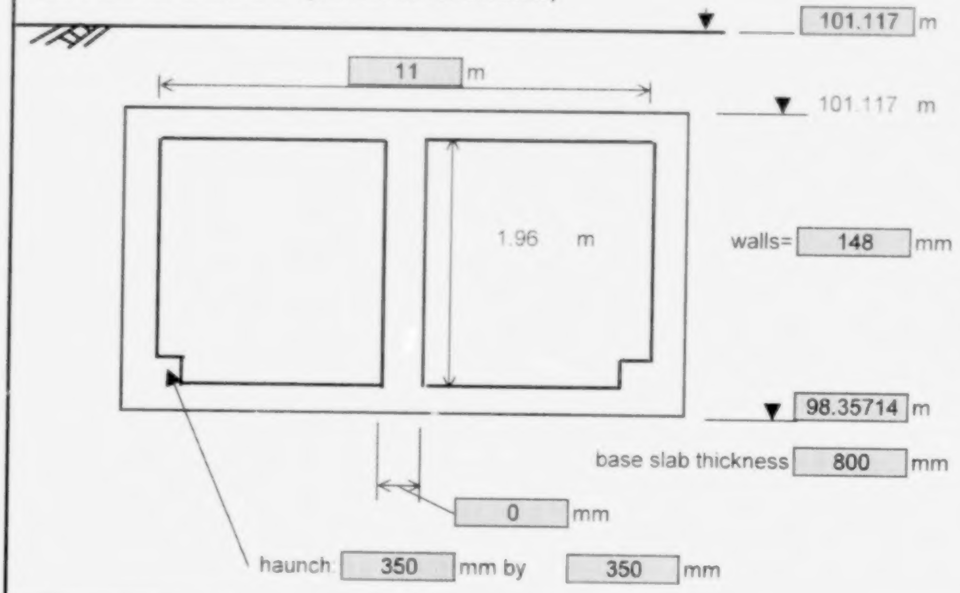
Section Cut and Cover
Length of section: 32.85714 m
Section 9

Input cross-section details (cut and cover solution)



walls= 148 mm

base slab thickness 800 mm

haunch 350 mm by 350 mm

Calculated Quantities

excavation=	1024.4	m3	
concrete=	324.0358	m3	
rebar=	38.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	128.8	m2	
SP&L<=4.6m deep	181.4	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	371.1543	m2	

Newfoundland Fixed Link Pre-feasibility Study
North Approach
Bored Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
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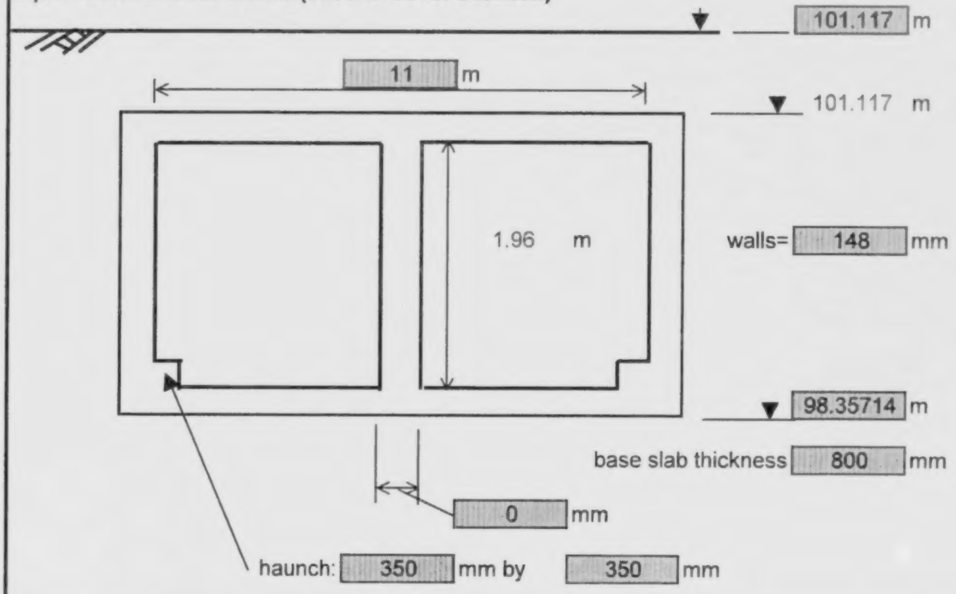
Section Cut and Cover
Length of section: 32.85714 m
Section 9

Input cross-section details (cut and cover solution)


101.117 m
11 m
101.117 m
1.96 m
walls= 148 mm
98.35714 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	1024.4	m3	
concrete=	324.0358	m3	
rebar=	38.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	128.8	m2	
SP&L<=4.6m deep	181.4	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	371.1543	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 2 of 2**

Calculated costs

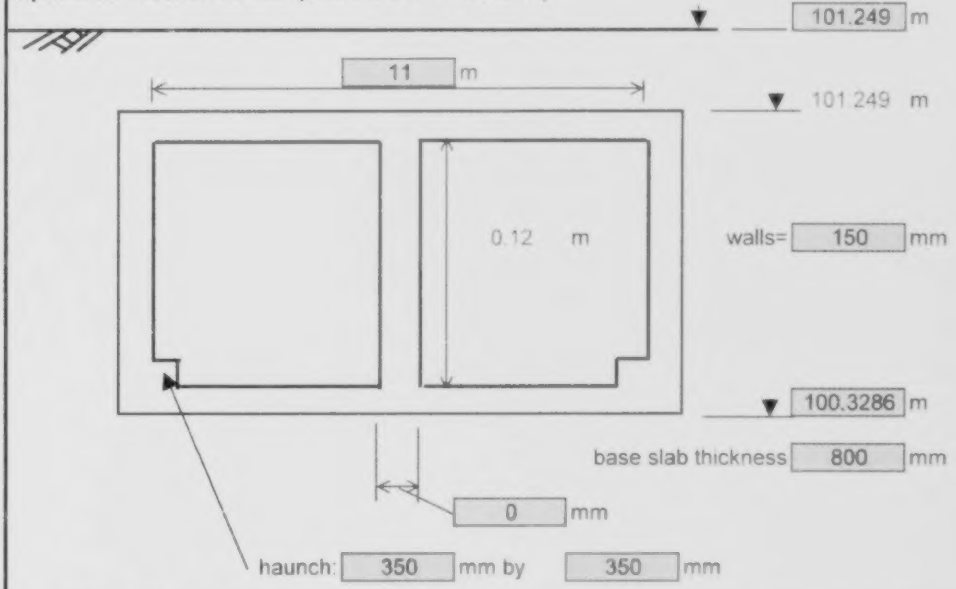
Item	Unit	Quantity	Rate	Cost
excavation	m3	1024.4	60	61463.15
concrete	m3	324.0358	190.0	61566.81
rebar	tonnes	38.9	1600	62214.88
formwork/falsework	m2	128.8	140	18032
SP&L<=4.6m deep	m2	181.4	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	371.1543	30	11134.63

Total 214411.5

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
North Approach	**Calculations by:** ANW
Bored Highway Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 32.85714 m **Section** **10**

Input cross-section details (cut and cover solution)



walls= 150 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

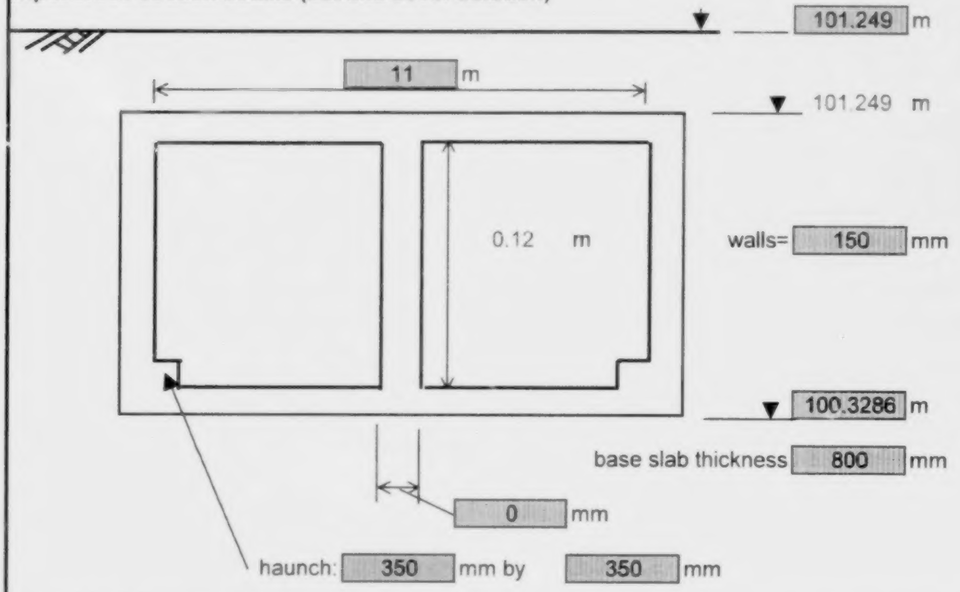
Calculated Quantities

excavation=	341.6	m3	
concrete=	306.2614	m3	
rebar=	36.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	7.885714	m2	
SP&L<=4.6m deep	60.5	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	371.2857	m2	

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
North Approach	**Calculations by:** ANW
Bored Highway Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 32.85714 m **Section** **10**

Input cross-section details (cut and cover solution)



walls= 150 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	341.6	m3	
concrete=	306.2614	m3	
rebar=	36.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	7.885714	m2	
SP&L<=4.6m deep	60.5	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	371.2857	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	341.6	60	20494.97
concrete	m3	306.2614	190.0	58189.67
rebar	tonnes	36.8	1600	58802.19
formwork/falsework	m2	7.885714	140	1104
SP&L<=4.6m deep	m2	60.5	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	371.2857	30	11138.57
			Total	149729.4

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Highway Tunnel

Summary of Costs

Markup for adjacent 0 %

Section	Cost
1	1115614
2	1010685
3	865475.2
4	765890.2
5	646183
6	490342.2
7	378671.1
8	291624.4
9	214411.5
10	149729.4
Sub-total	5928626

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: South Approach
Option: Bored Highway Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient	0	%	+ sloping same way as track/road - sloping against track/road
Track/Road Gradient	3	%	
Ground elevation at portal	100	m	
Bottom of slab elevation at portal	55	m	
Total length=	1500	m	
Total Cost=$	39.5	M	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Highway Tunnel

Summary of Costs

Markup for adjacent 0 %

Section	Cost
1	1115614
2	1010685
3	865475.2
4	765890.2
5	646183
6	490342.2
7	378671.1
8	291624.4
9	214411.5
10	149729.4
Sub-total	5928626

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: South Approach
Option: Bored Highway Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient	0	%
Track/Road Gradient	3	%
Ground elevation at portal	100	m
Bottom of slab elevation at portal	55	m

+ sloping same way as track/road
- sloping against track/road

Total length=	1500	m
Total Cost=$	39.5	M

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: South Approach
Option: Bored Highway Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient 0.55 %
+ sloping same way as track/road
- sloping against track/road

Track/Road Gradient 6 %

Ground elevation at portal 100 m

Bottom of slab elevation at portal 81.6 m

Total length= 337.6147 m

Total Cost=$ 6.1 M

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel

UNIT RATES

Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: South Approach
Option: Bored Highway Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient	0.55	%	+ sloping same way as track/road - sloping against track/road
Track/Road Gradient	6	%	
Ground elevation at portal	100	m	
Bottom of slab elevation at portal	81.6	m	

Total length= 337.6147 m

Total Cost=$ 6.1 M

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel

UNIT RATES

Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
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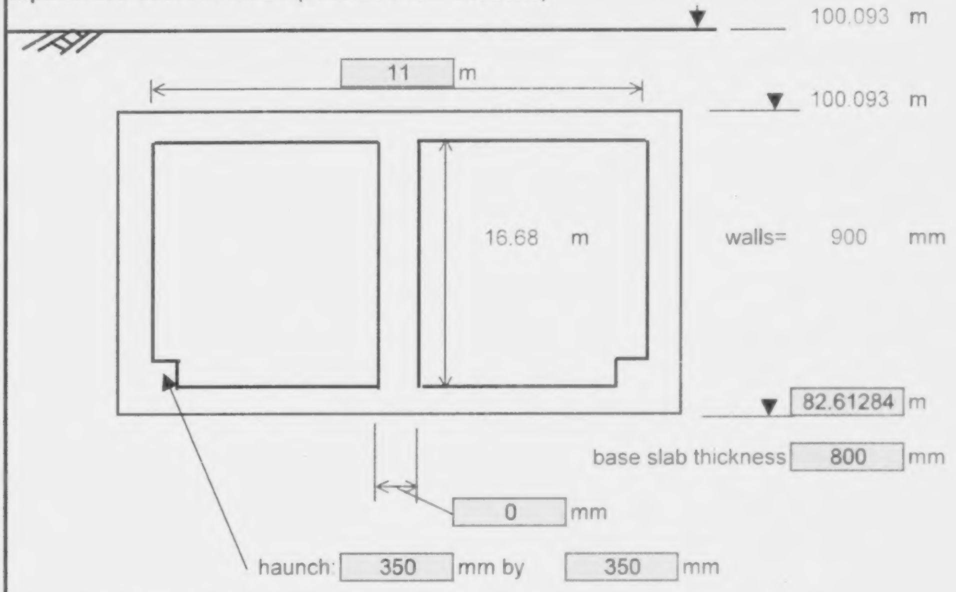
Section Cut and Cover
Length of section: 33.76147 m
Section 1

Input cross-section details (cut and cover solution)


100.093 m
11 m
100.093 m
16.68 m
walls= 900 mm
82.61284 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

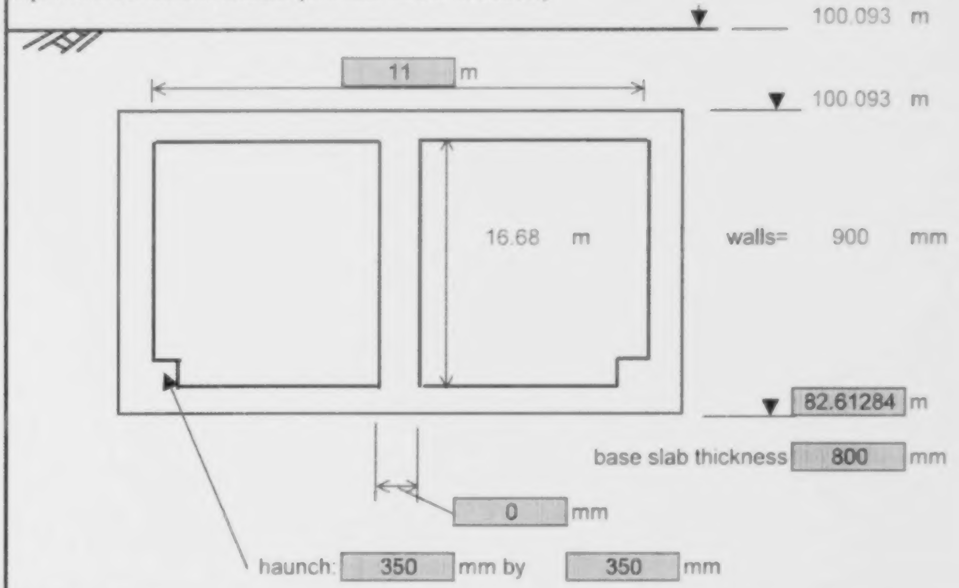
Calculated Quantities

excavation=	7553.9	m3	
concrete=	1367.643	m3	
rebar=	164.1	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1126.283	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	1180.3	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	432.1468	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 33.76147 m **Section** **1**

Input cross-section details (cut and cover solution)



100.093 m
11 m
100.093 m
16.68 m
walls= 900 mm
82.61284 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation= 7553.9 m3
concrete= 1367.643 m3
rebar= 164.1 tonnes (assume 0.12t/m3 of concrete)
formwork/falsework= 1126.283 m2
SP&L<=4.6m deep 0.0 m2
4.6<SP&L<=6.7m deep 0.0 m2
6.7<SP&L<=10.6m deep 0.0 m2
10.6<SP&L<=13.7m deep 0.0 m2
13.7<SP&L<=16.8m deep 0.0 m2
16.8<SP&L<=20.0m deep 1180.3 m2
20<SP&L<=25m deep 0.0 m2
backfill= 0 m3
surface reinstatement= 432.1468 m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	7553.9	60	453235.6
concrete	m3	1367.643	190.0	259852.2
rebar	tonnes	164.1	1600	262587.5
formwork/falsework	m2	1126.283	140	157679.6
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	1180.3	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	432.1468	30	12964.4
			Total	1146319

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
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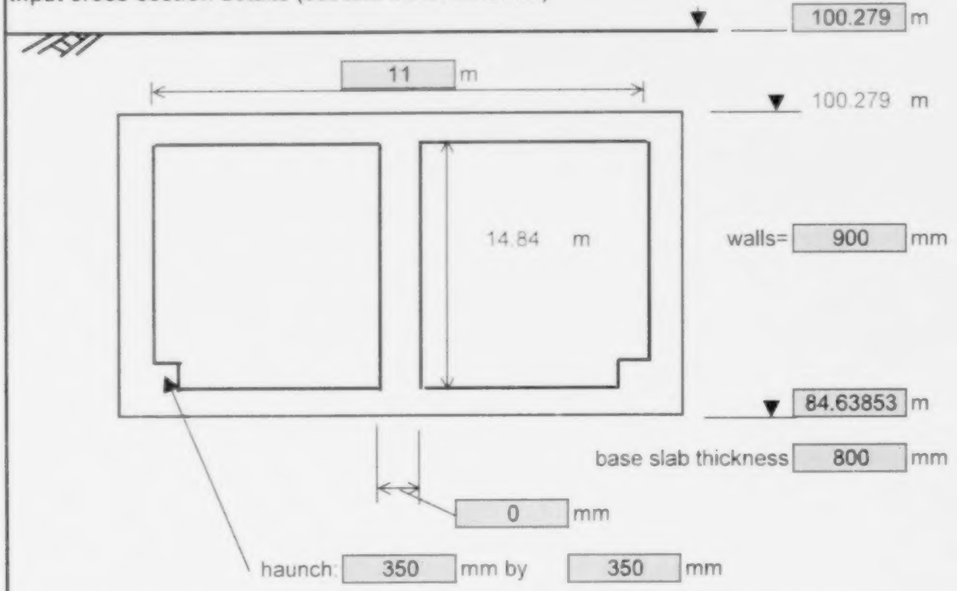
Bored Highway Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 33.76147 m **Section** 2

Input cross-section details (cut and cover solution)



100.279 m
11 m
100.279 m
14.84 m
walls= 900 mm
84.63853 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

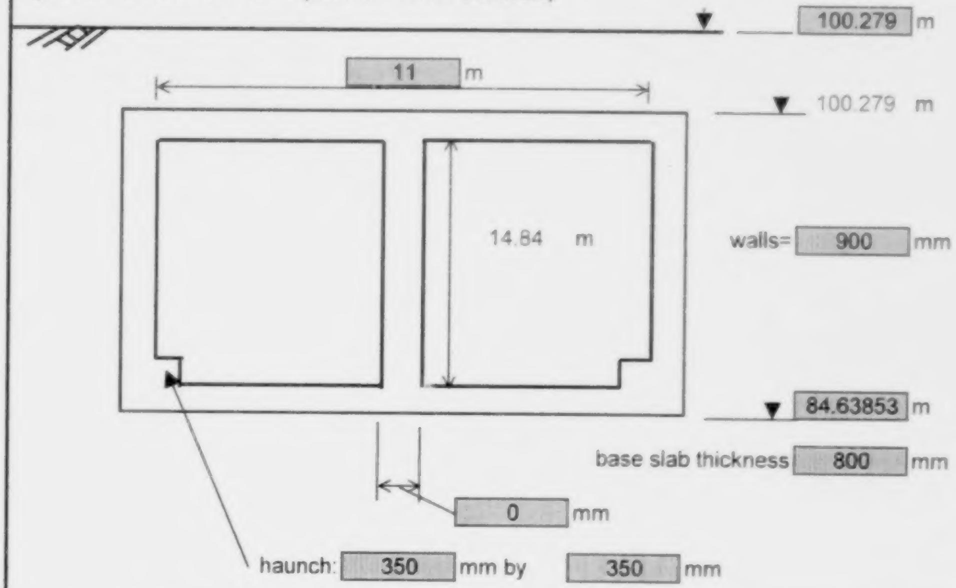
Calculated Quantities

excavation=	6758.8	m3	
concrete=	1255.825	m3	
rebar=	150.7	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1002.04	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	1056.1	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	432.1468	m2	

Newfoundland Fixed Link Pre-feasibility Study Date: 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 33.76147 m **Section 2**

Input cross-section details (cut and cover solution)


100.279 m
11 m
100.279 m
14.84 m
walls= 900 mm
84.63853 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	6758.8	m3	
concrete=	1255.825	m3	
rebar=	150.7	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1002.04	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	1056.1	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	432.1468	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	6758.8	60	405526.5
concrete	m3	1255.825	190.0	238606.8
rebar	tonnes	150.7	1600	241118.5
formwork/falsework	m2	1002.04	140	140285.7
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	1056.1	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	432.1468	30	12964.4
			Total	1038502

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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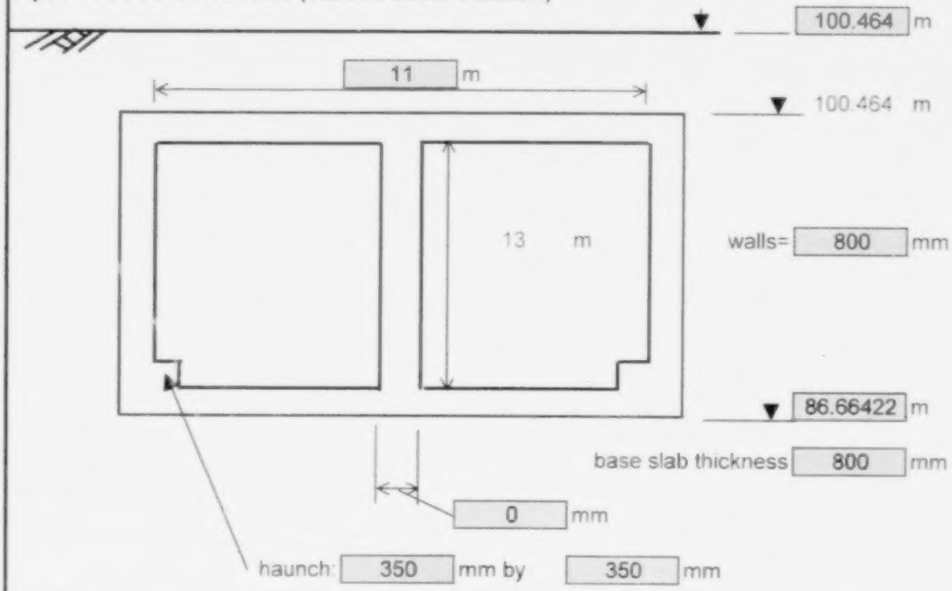
Section Cut and Cover
Length of section: 33.76147 m **Section 3**

Input cross-section details (cut and cover solution)



100.464 m
11 m
100.464 m
13 m
walls= 800 mm
86.66422 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	5870.4	m3	
concrete=	1050.826	m3	
rebar=	126.1	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	877.7982	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	931.8	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	425.3945	m2	

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Bored Highway Tunnel

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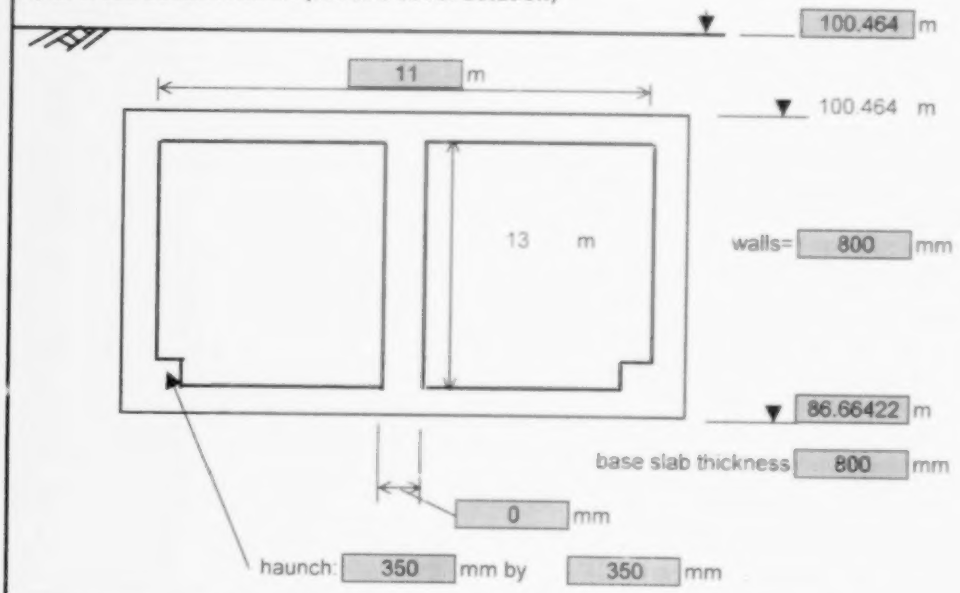
Section Cut and Cover
Length of section: 33.76147 m
Section 3

Input cross-section details (cut and cover solution)



walls= 800 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	5870.4	m3	
concrete=	1050.826	m3	
rebar=	126.1	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	877.7982	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	931.8	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	425.3945	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	5870.4	60	352226.6
concrete	m3	1050.826	190.0	199656.9
rebar	tonnes	126.1	1600	201758.5
formwork/falsework	m2	877.7982	140	122891.7
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	931.8	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	425.3945	30	12761.83
			Total	889295.6

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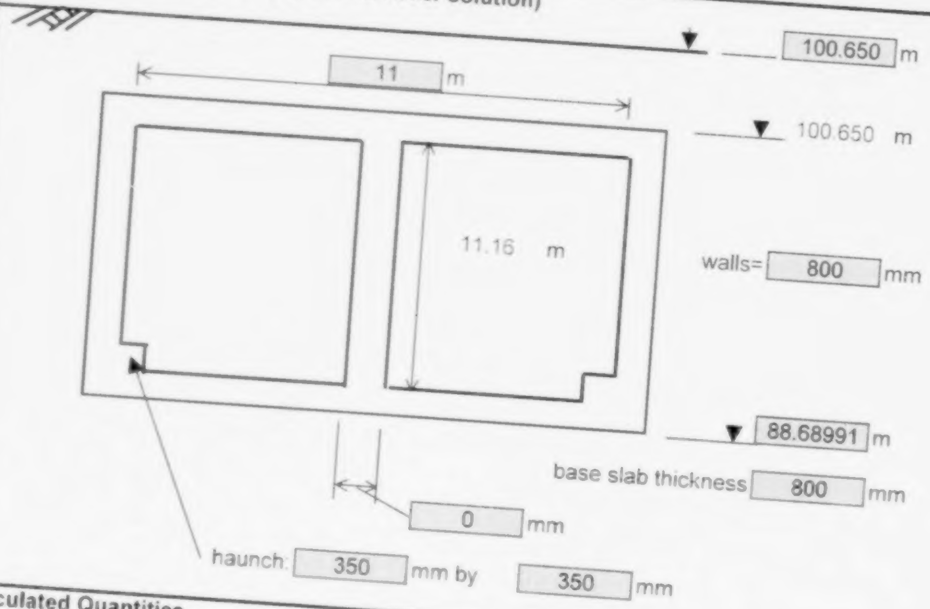
Section Cut and Cover
Length of section: 33.76147 m
Section 4

Input cross-section details (cut and cover solution)



100.650 m
11 m
100.650 m
11.16 m
walls= 800 mm
88.68991 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	5087.7	m3	
concrete=	951.4319	m3	
rebar=	114.2	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	753.556	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	807.6	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	425.3945	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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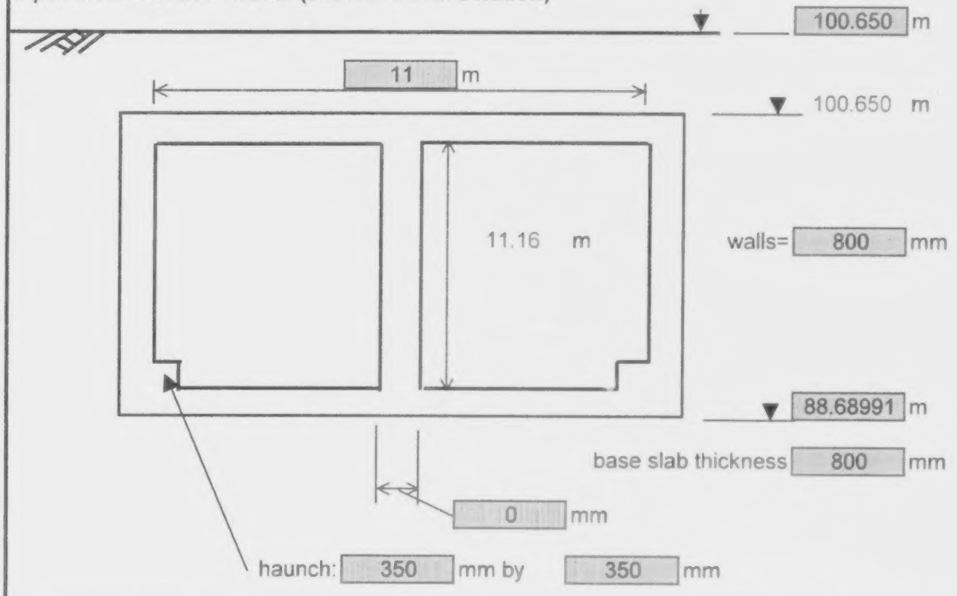
Section Cut and Cover
Length of section: 33.76147 m **Section 4**

Input cross-section details (cut and cover solution)



walls= 800 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	5087.7	m3	
concrete=	951.4319	m3	
rebar=	114.2	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	753.556	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	807.6	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	425.3945	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	5087.7	60	305263.1
concrete	m3	951.4319	190.0	180772.1
rebar	tonnes	114.2	1600	182674.9
formwork/falsework	m2	753.556	140	105497.8
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	807.6	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	425.3945	30	12761.83
			Total	786969.8

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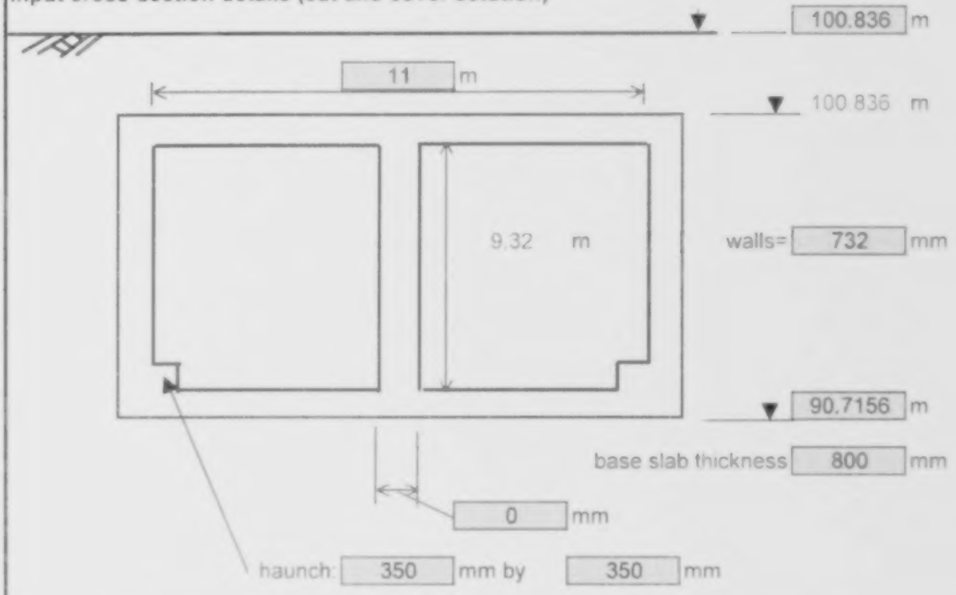
Section Cut and Cover
Length of section: 33.76147 m **Section 5**

Input cross-section details (cut and cover solution)



walls= 732 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	4258.5	m3	
concrete=	805.5716	m3	
rebar=	96.7	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	629.3138	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	683.3	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	420.8029	m2	

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Bored Highway Tunnel

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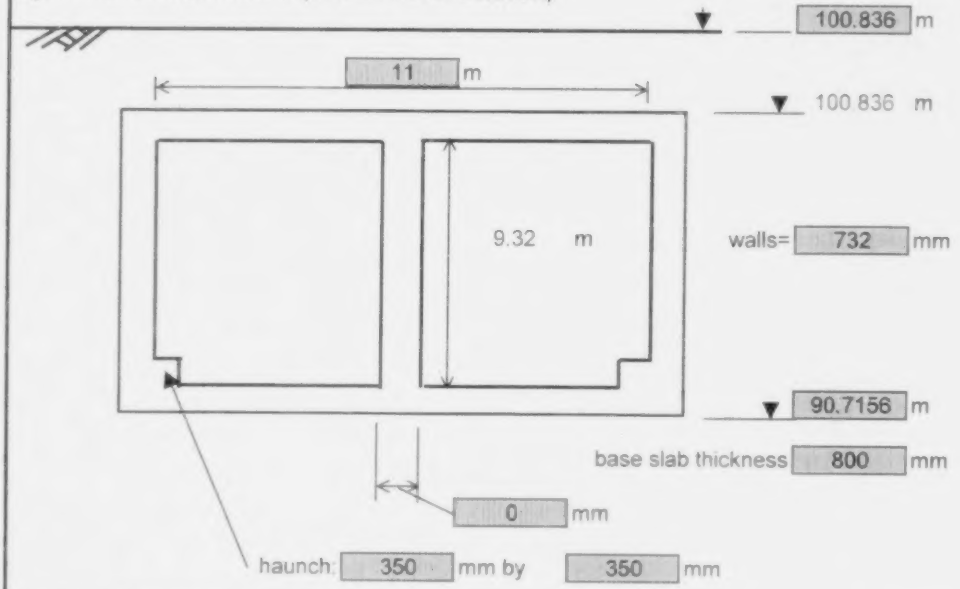
Section Cut and Cover
Length of section: 33.76147 m
Section 5

Input cross-section details (cut and cover solution)


100.836 m
11 m
100.836 m
9.32 m
walls= 732 mm
90.7156 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	4258.5	m3	
concrete=	805.5716	m3	
rebar=	96.7	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	629.3138	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	683.3	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	420.8029	m2	

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South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	4258.5	60	255511.5
concrete	m3	805.5716	190.0	153058.6
rebar	tonnes	96.7	1600	154669.7
formwork/falsework	m2	629.3138	140	88103.93
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	683.3	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	420.8029	30	12624.09
			Total	663967.9

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Highway Tunnel

Date: 8-Jun-04
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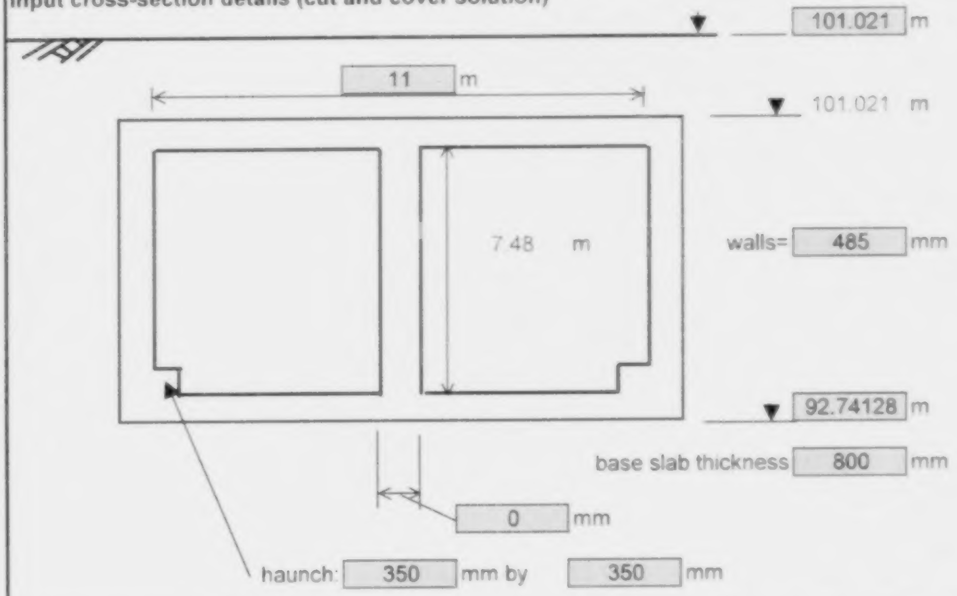
Section Cut and Cover
Length of section: 33.76147 m

Section 6

Input cross-section details (cut and cover solution)



101.021 m
11 m
101.021 m
7.48 m
walls= 485 mm
92.74128 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	3346.2	m3	
concrete=	576.5311	m3	
rebar=	69.2	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	505.0716	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	559.1	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	404.1248	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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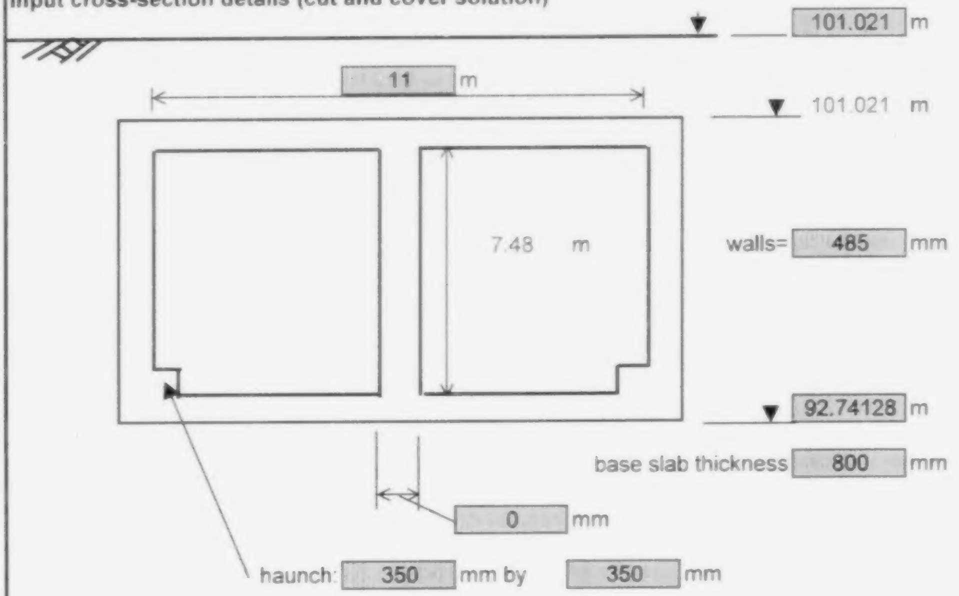
Section Cut and Cover
Length of section: 33.76147 m **Section 6**

Input cross-section details (cut and cover solution)



101.021 m
11 m
101.021 m
7.48 m
walls= 485 mm
92.74128 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	3346.2	m3	
concrete=	576.5311	m3	
rebar=	69.2	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	505.0716	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	559.1	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	404.1248	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	3346.2	60	200769.2
concrete	m3	576.5311	190.0	109540.9
rebar	tonnes	69.2	1600	110694
formwork/falsework	m2	505.0716	140	70710.02
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	559.1	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	404.1248	30	12123.74
			Total	503837.8

Newfoundland Fixed Link Pre-feasibility Study
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Calculations by: ANW
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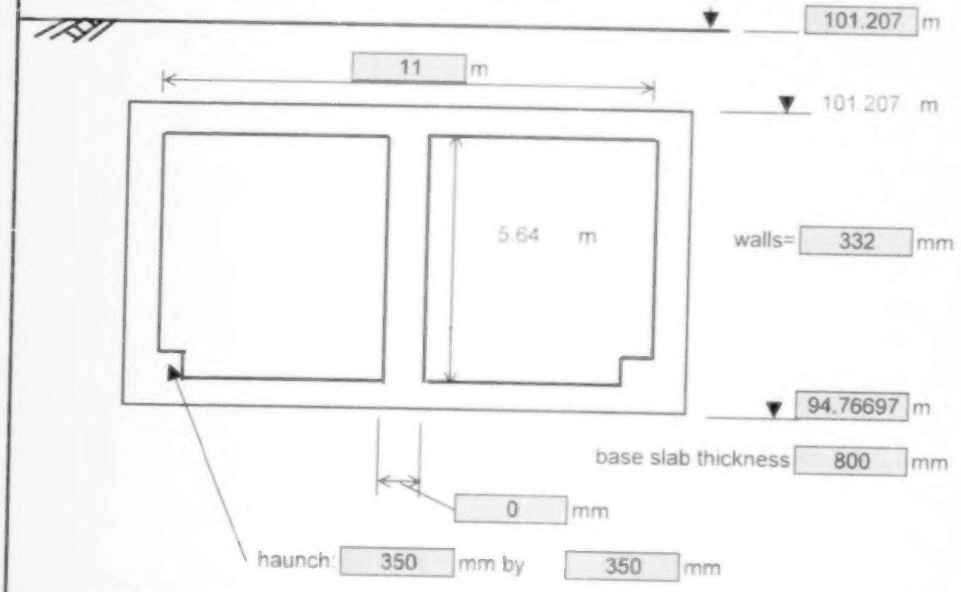
Section Cut and Cover
Length of section: 33.76147 m
Section 7

Input cross-section details (cut and cover solution)



101.207 m
11 m
101.207 m
5.64 m
walls= 332 mm
94.76697 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation= 2536.0 m3
concrete= 449.7419 m3
rebar= 54.0 tonnes (assume 0.12t/m3 of concrete)
formwork/falsework= 380.8294 m2
SP&L<=4.6m deep 0.0 m2
4.6<SP&L<=6.7m deep 434.8 m2
6.7<SP&L<=10.6m deep 0.0 m2
10.6<SP&L<=13.7m deep 0.0 m2
13.7<SP&L<=16.8m deep 0.0 m2
16.8<SP&L<=20.0m deep 0.0 m2
20<SP&L<=25m deep 0.0 m2
backfill= 0 m3
surface reinstatement= 393.7938 m2

Newfoundland Fixed Link Pre-feasibility Study
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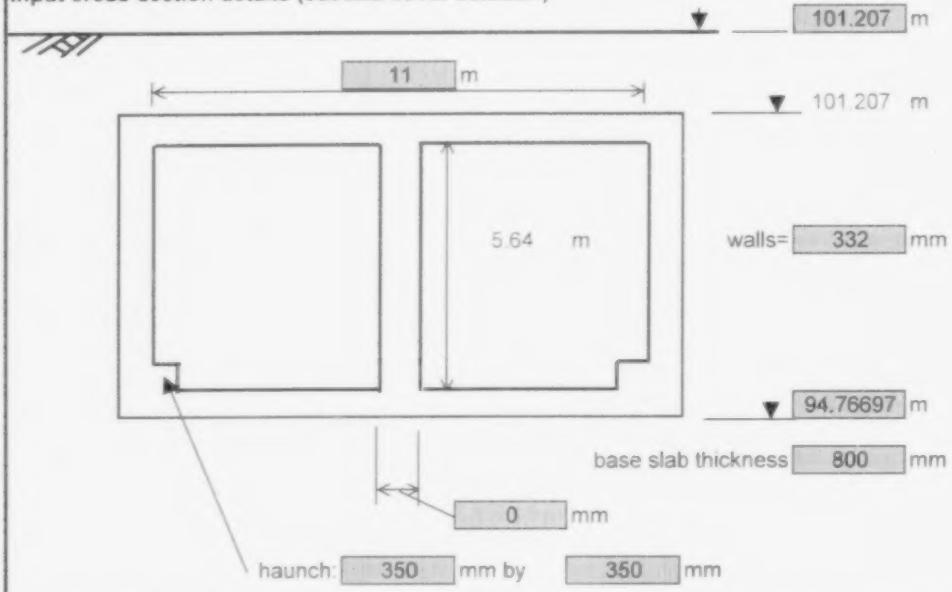
Section Cut and Cover
Length of section: 33.76147 m
Section 7

Input cross-section details (cut and cover solution)


101.207 m
11 m
101.207 m
5.64 m
walls= 332 mm
94.76697 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	2536.0	m3	
concrete=	449.7419	m3	
rebar=	54.0	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	380.8294	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	434.8	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	393.7938	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 2 of 2**

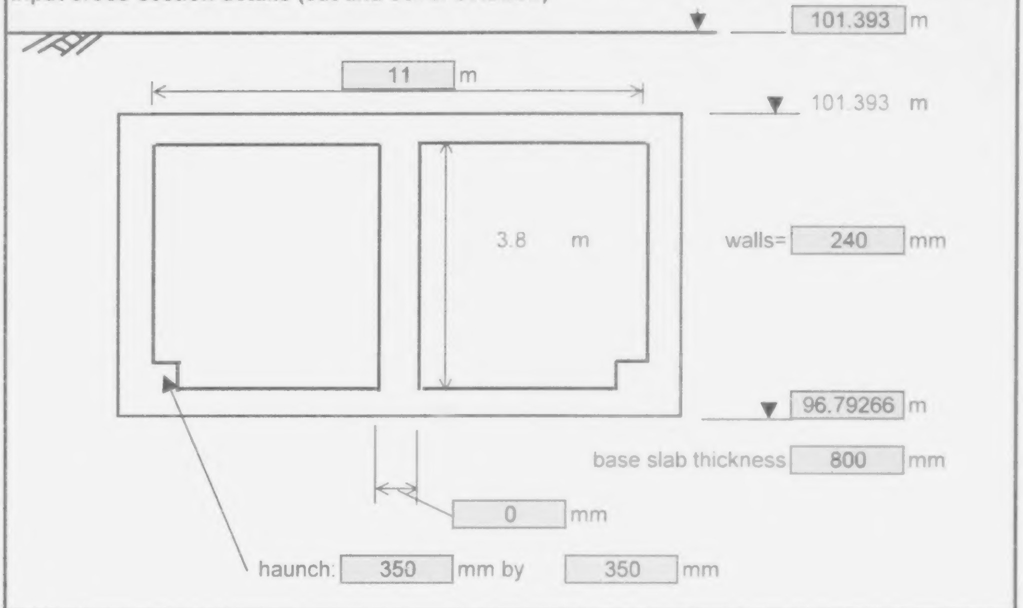
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	2536.0	60	152161.9
concrete	m3	449.7419	190.0	85450.96
rebar	tonnes	54.0	1600	86350.45
formwork/falsework	m2	380.8294	140	53316.11
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	434.8	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<[illegible]m deep	m2	0.0	0	0
16.8<SP&L<[illegible] deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	393.7938	30	11813.81
			Total	389093.2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 33.76147 m **Section** **8**

Input cross-section details (cut and cover solution)



101.393 m
11 m
101.393 m
3.8 m
walls= 240 mm
96.79266 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

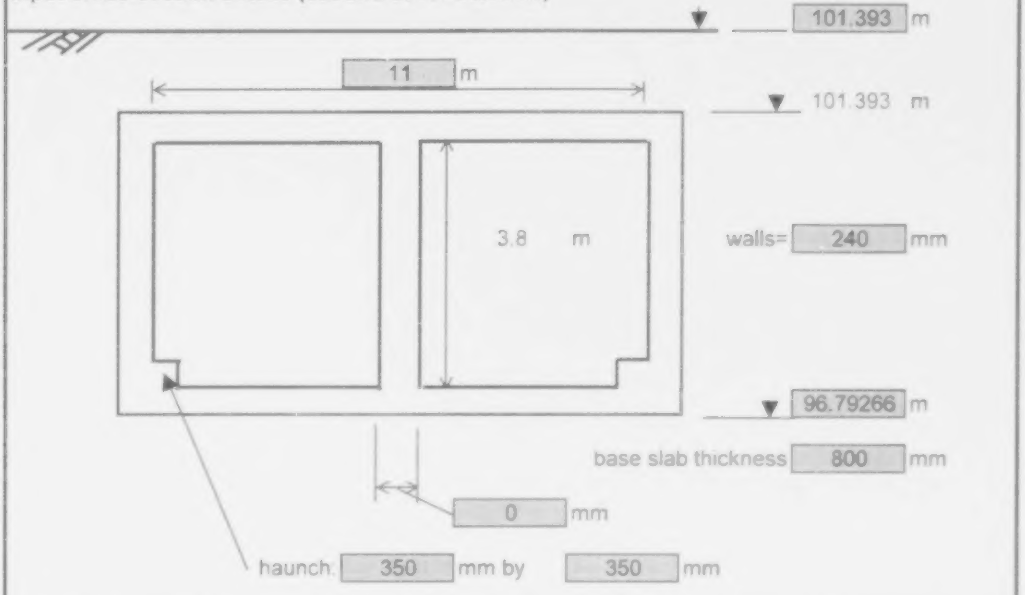
Calculated Quantities

excavation=	1782.9	m3	
concrete=	379.9178	m3	
rebar=	45.6	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	256.5872	m2	
SP&L<=4.6m deep	310.6	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	387.5817	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 33.76147 m **Section** **8**

Input cross-section details (cut and cover solution)



101.393 m
11 m
101.393 m
3.8 m
walls= 240 mm
96.79266 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	1782.9	m3
concrete=	379.9178	m3
rebar=	45.6	tonnes (assume 0.12t/m3 of concrete)
formwork/falsework=	256.5872	m2
SP&L<=4.6m deep	310.6	m2
4.6<SP&L<=6.7m deep	0.0	m2
6.7<SP&L<=10.6m deep	0.0	m2
10.6<SP&L<=13.7m deep	0.0	m2
13.7<SP&L<=16.8m deep	0.0	m2
16.8<SP&L<=20.0m deep	0.0	m2
20<SP&L<=25m deep	0.0	m2
backfill=	0	m3
surface reinstatement=	387.5817	m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 2 of 2**

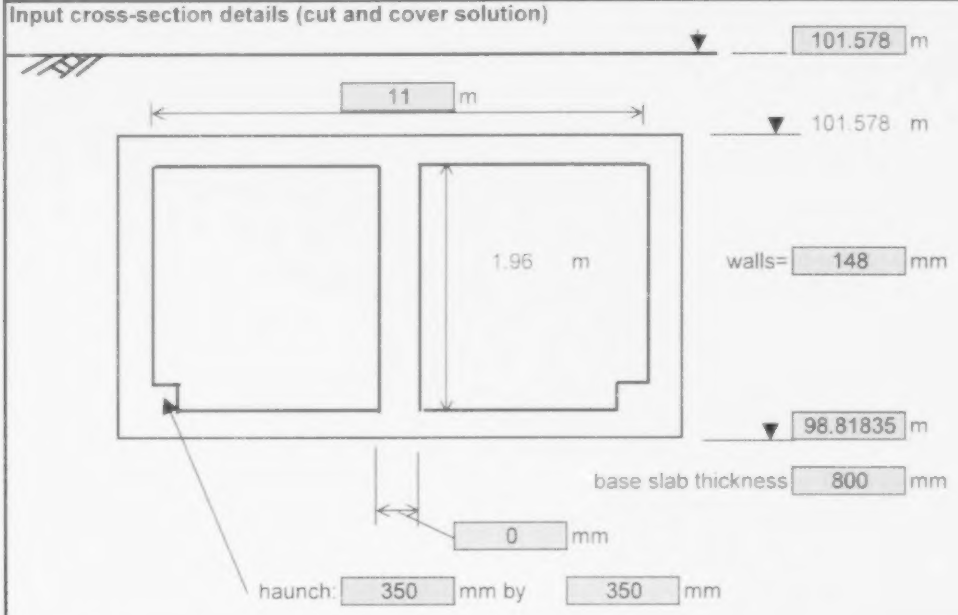
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	1782.9	60	106972.5
concrete	m3	379.9178	190.0	72184.38
rebar	tonnes	45.6	1600	72944.22
formwork/falsework	m2	256.5872	140	35922.2
SP&L<=4.6m deep	m2	310.6	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	387.5817	30	11627.45
			Total	299650.8

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 33.76147 m **Section** 9

Input cross-section details (cut and cover solution)


101.578 m
11 m
101.578 m
1.96 m
walls= 148 mm
98.81835 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	1052.6	m3	
concrete=	332.9542	m3	
rebar=	40.0	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	132.345	m2	
SP&L<=4.6m deep	186.4	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	381.3695	m2	

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
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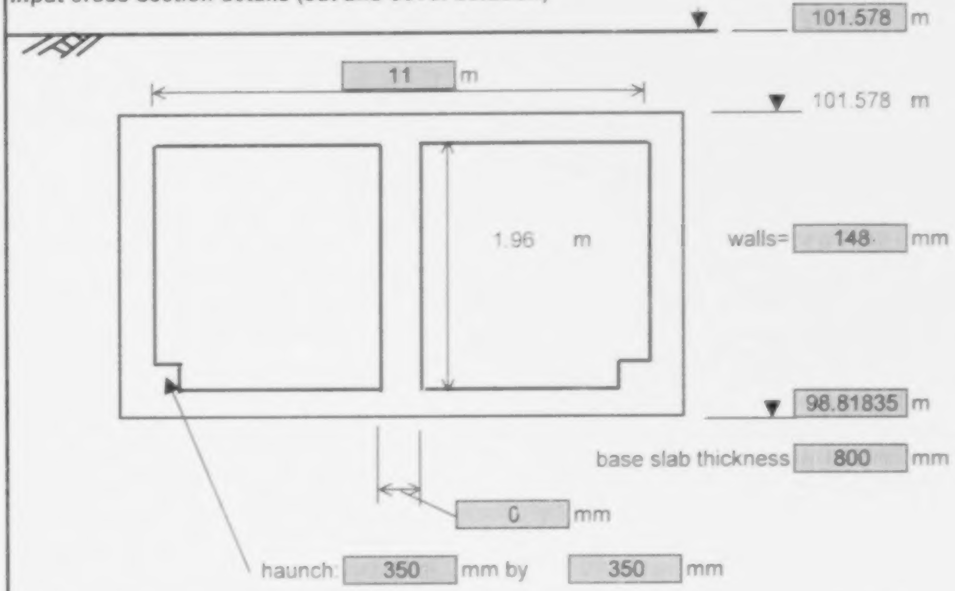
Section Cut and Cover
Length of section: 33.76147 m
Section 9

Input cross-section details (cut and cover solution)



101.578 m
11 m
101.578 m
1.96 m
walls= 148 mm
98.81835 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation= 1052.6 m3
concrete= 332.9542 m3
rebar= 40.0 tonnes (assume 0.12t/m3 of concrete)
formwork/falsework= 132.345 m2
SP&L<=4.6m deep 186.4 m2
4.6<SP&L<=6.7m deep 0.0 m2
6.7<SP&L<=10.6m deep 0.0 m2
10.6<SP&L<=13.7m deep 0.0 m2
13.7<SP&L<=16.8m deep 0.0 m2
16.8<SP&L<=20.0m deep 0.0 m2
20<SP&L<=25m deep 0.0 m2
backfill= 0 m3
surface reinstatement= 381.3695 m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	1052.6	60	63154.8
concrete	m3	332.9542	190.0	63261.31
rebar	tonnes	40.0	1600	63927.22
formwork/falsework	m2	132.345	140	18528.29
SP&L<=4.6m deep	m2	186.4	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	381.3695	30	11441.09
			Total	220312.7

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
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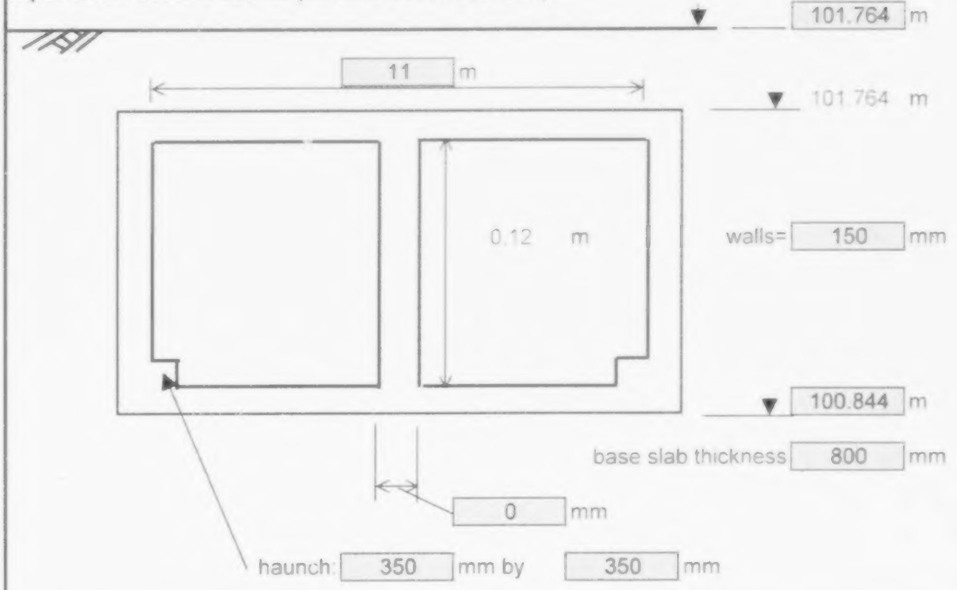
Section Cut and Cover
Length of section: 33.76147 m
Section **10**

Input cross-section details (cut and cover solution)


101.764 m
11 m
101.764 m
0.12 m
walls= 150 mm
100.844 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

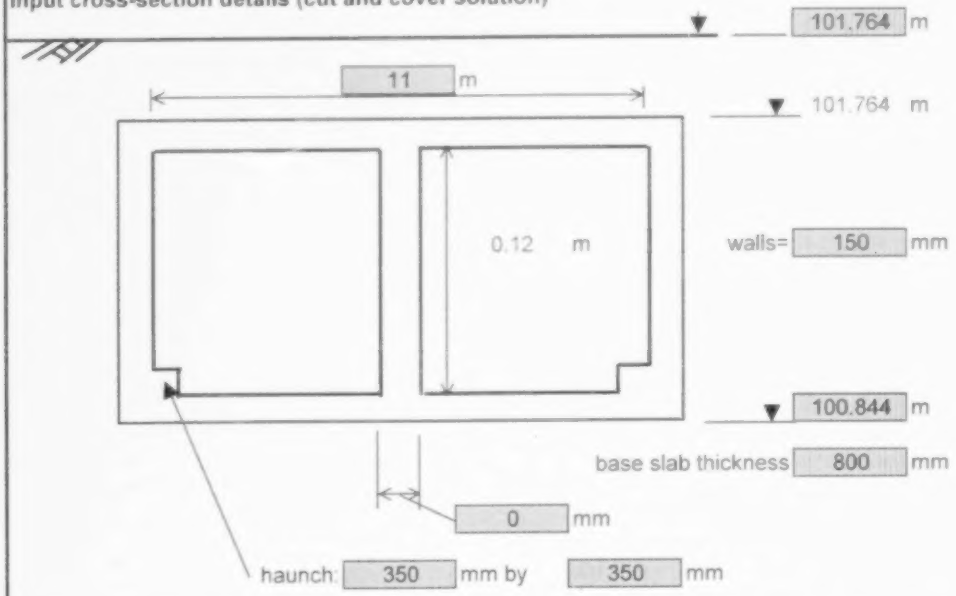
excavation=	351.0	m3	
concrete=	314.6906	m3	
rebar=	37.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	8.102752	m2	
SP&L<=4.6m deep	62.1	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	381.5046	m2	

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
Bored Highway Tunnel	**Page 1 of 2**

Section Cut and Cover

Length of section: 33.76147 m **Section** **10**

Input cross-section details (cut and cover solution)


101.764 m
11 m
101.764 m
0.12 m
walls= 150 mm
100.844 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	351.0	m3	
concrete=	314.6906	m3	
rebar=	37.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	8.102752	m2	
SP&L<=4.6m deep	62.1	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	381.5046	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	351.0	60	21059.05
concrete	m3	314.6906	190.0	59791.22
rebar	tonnes	37.8	1600	60420.6
formwork/falsework	m2	8.102752	140	1134.385
SP&L<=4.6m deep	m2	62.1	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	381.5046	30	11445.14
			Total	153850.4

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel

Summary of Costs

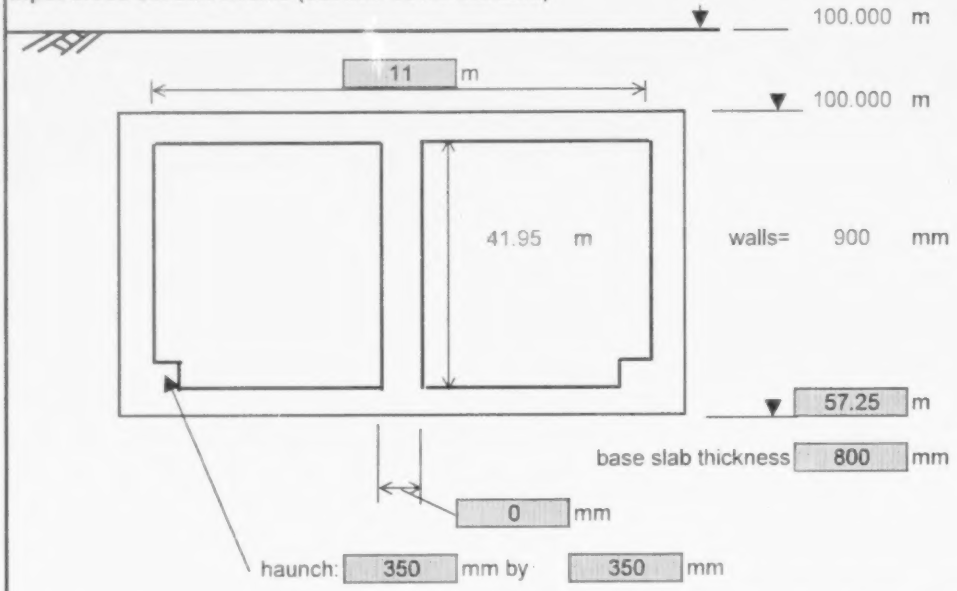
Markup for adjacent 0 %

Section	**Cost**
1	1146319
2	1038502
3	889295.6
4	786969.8
5	663967.9
6	503837.8
7	389093.2
8	299650.8
9	220312.7
10	153850.4
Sub-total	6091799

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 150 m **Section 1**

Input cross-section details (cut and cover solution)



100.000 m
11 m
100.000 m
41.95 m
walls= 900 mm
57.25 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	82080.0	m3	
concrete=	12899.25	m3	
rebar=	1547.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	12585	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	1920	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel

Summary of Costs

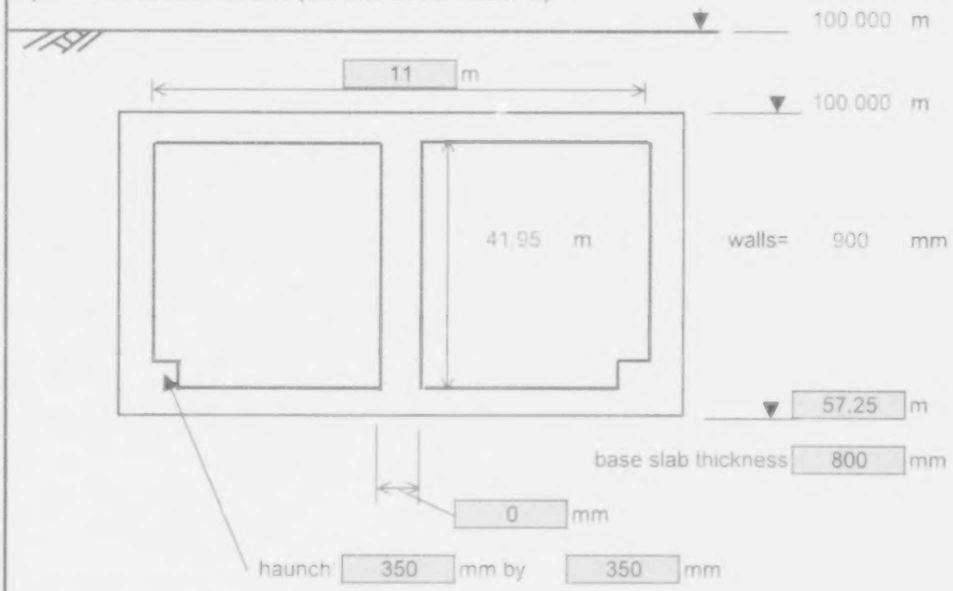
Markup for adjacent 0 %

Section	Cost
1	1146319
2	1038502
3	889295.6
4	786969.8
5	663967.9
6	503837.8
7	389093.2
8	299650.8
9	220312.7
10	153850.4
Sub-total	6091799

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 150 m **Section 1**

Input cross-section details (cut and cover solution)


100.000 m
11 m
100.000 m
41.95 m
walls= 900 mm
57.25 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	82080.0	m3	
concrete=	12899.25	m3	
rebar=	1547.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	12585	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	1920	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 2 of 2**

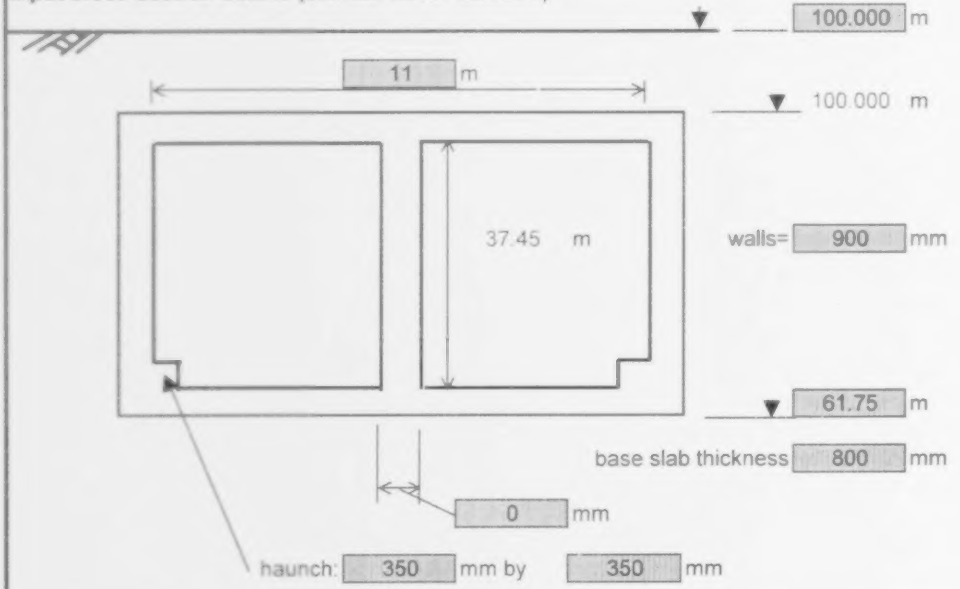
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	82080.0	60	4924800
concrete	m3	12899.25	190.0	2450858
rebar	tonnes	1547.9	1600	2476656
formwork/falsework	m2	12585	140	1761900
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	1920	30	57600
			Total	11671814

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 150 m **Section** 2

Input cross-section details (cut and cover solution)


100.000 m
11 m
100.000 m
37.45 m
walls= 900 mm
61.75 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

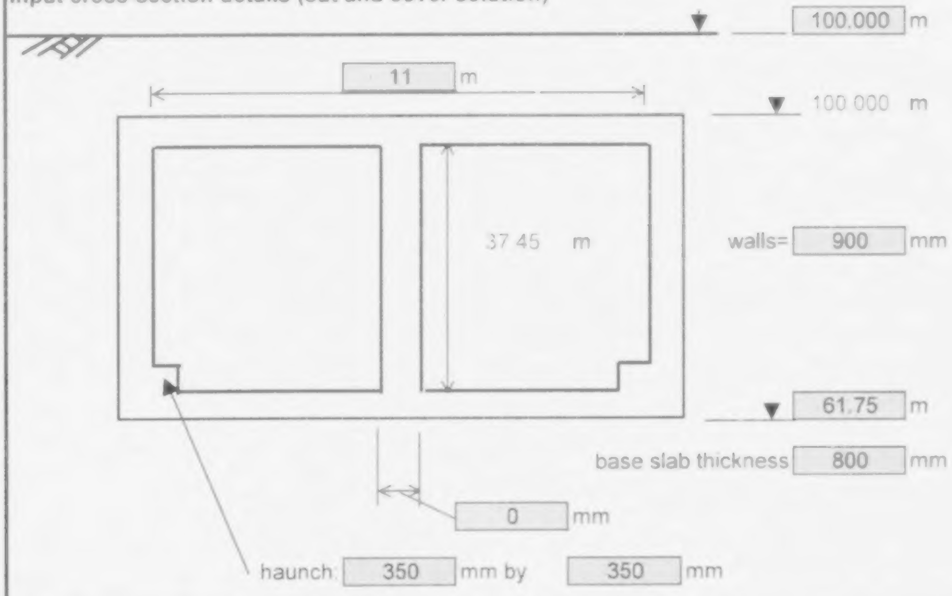
Calculated Quantities

excavation=	73440.0	m3	
concrete=	11684.25	m3	
rebar=	1402.1	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	11235	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	1920	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 150 m **Section 2**

Input cross-section details (cut and cover solution)


100.000 m
11 m
100.000 m
37.45 m
walls= 900 mm
61.75 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation= 73440.0 m3
concrete= 11684.25 m3
rebar= 1402.1 tonnes (assume 0.12t/m3 of concrete)
formwork/falsework= 11235 m2
SP&L<=4.6m deep 0.0 m2
4.6<SP&L<=6.7m deep 0.0 m2
6.7<SP&L<=10.6m deep 0.0 m2
10.6<SP&L<=13.7m deep 0.0 m2
13.7<SP&L<=16.8m deep 0.0 m2
16.8<SP&L<=20.0m deep 0.0 m2
20<SP&L<=25m deep 0.0 m2
backfill= 0 m3
surface reinstatement= 1920 m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel **Page 2 of 2**

Calculated costs

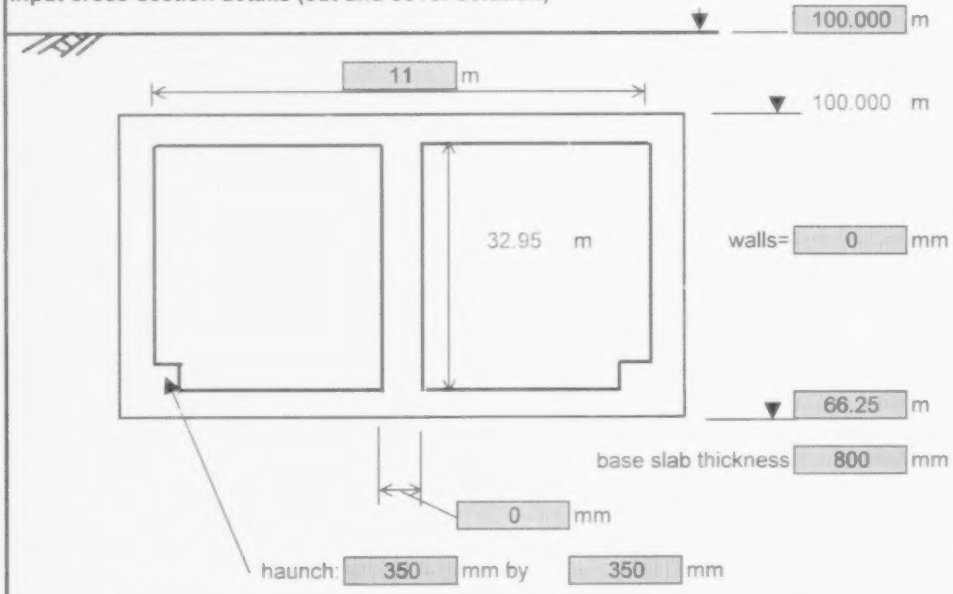
Item	Unit	Quantity	Rate	Cost
excavation	m3	73440.0	60	4406400
concrete	m3	11684.25	190.0	2220008
rebar	tonnes	1402.1	1600	2243376
formwork/falsework	m2	11235	140	1572900
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	1920	30	57600
			Total	10500284

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
Bored Highway Tunnel	**Page 1 of 2**

Section Cut and Cover

Length of section: 150 m **Section** 3

Input cross-section details (cut and cover solution)


100.000 m
11 m
100.000 m
32.95 m
walls= 0 mm
66.25 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	55687.5	m3	
concrete=	1356.75	m3	
rebar=	162.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	9885	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	1650	m2	

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
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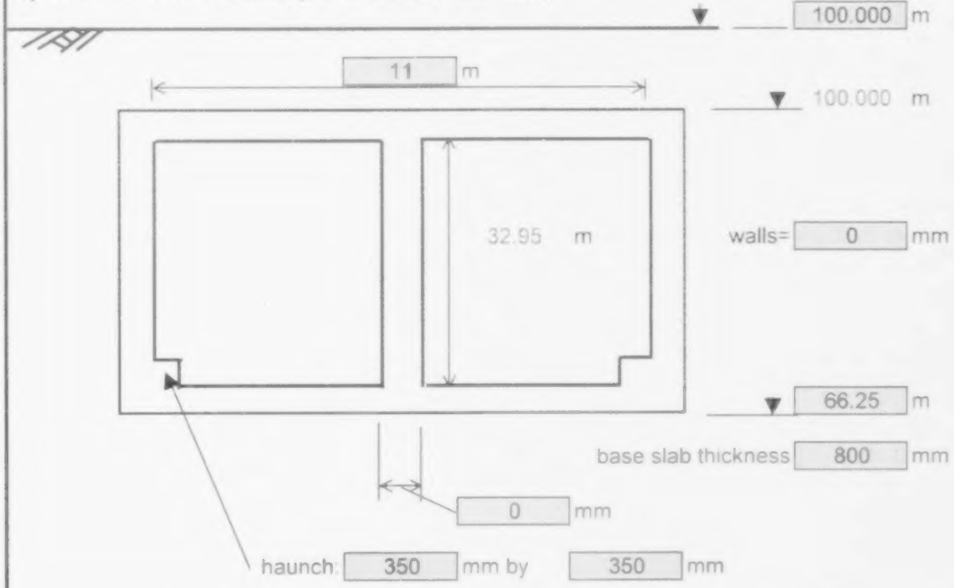
Section Cut and Cover
Length of section: 150 m **Section** 3

Input cross-section details (cut and cover solution)


100.000 m
11 m
100.000 m
32.95 m
walls= 0 mm
66.25 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	55687.5	m3	
concrete=	1356.75	m3	
rebar=	162.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	9885	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	1650	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	55687.5	60	3341250
concrete	m3	1356.75	190.0	257782.5
rebar	tonnes	162.8	1600	260496
formwork/falsework	m2	9885	140	1383900
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	1650	30	49500
			Total	5292929

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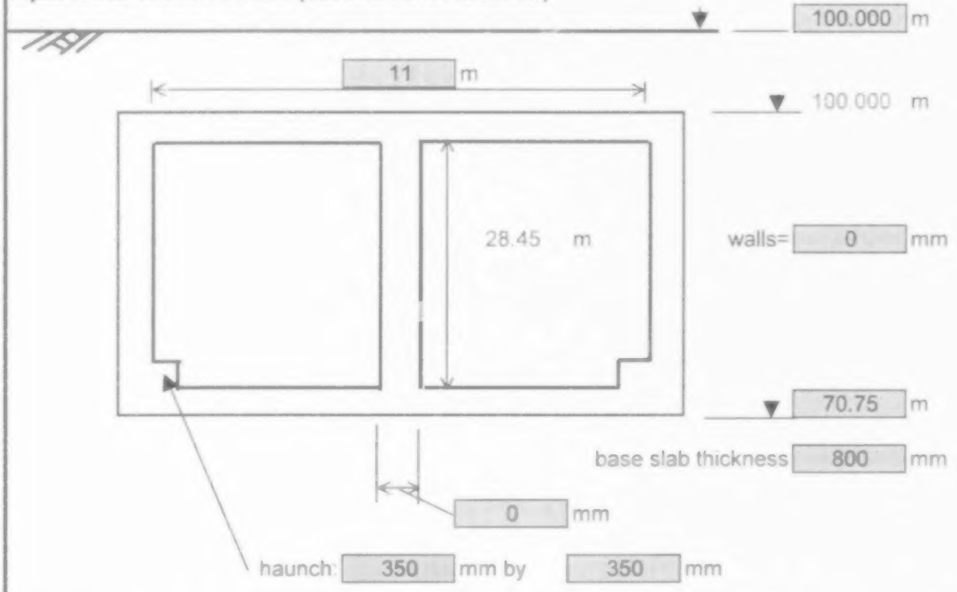
Section Cut and Cover
Length of section: 150 m **Section** **4**

Input cross-section details (cut and cover solution)



100.000 m
11 m
100.000 m
28.45 m
walls= 0 mm
70.75 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	48262.5	m3	
concrete=	1356.75	m3	
rebar=	162.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	8535	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	1650	m2	

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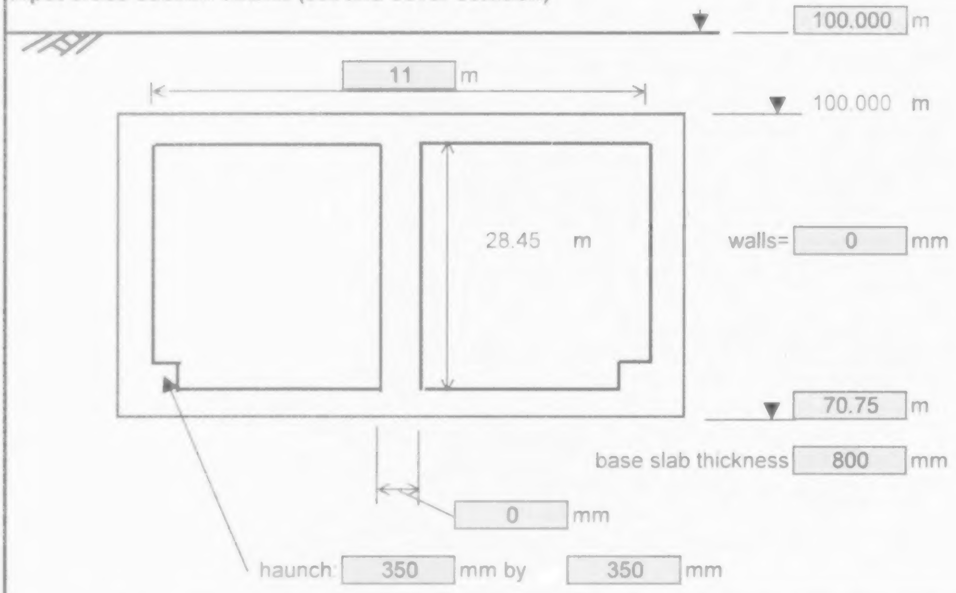
Section Cut and Cover
Length of section: 150 m **Section** 4

Input cross-section details (cut and cover solution)


100.000 m
11 m
100.000 m
28.45 m
walls= 0 mm
70.75 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	48262.5	m3	
concrete=	1356.75	m3	
rebar=	162.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	8535	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	1650	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	48262.5	60	2895750
concrete	m3	1356.75	190.0	257782.5
rebar	tonnes	162.8	1600	260496
formwork/falsework	m2	8535	140	1194900
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	1650	30	49500
			Total	4658429

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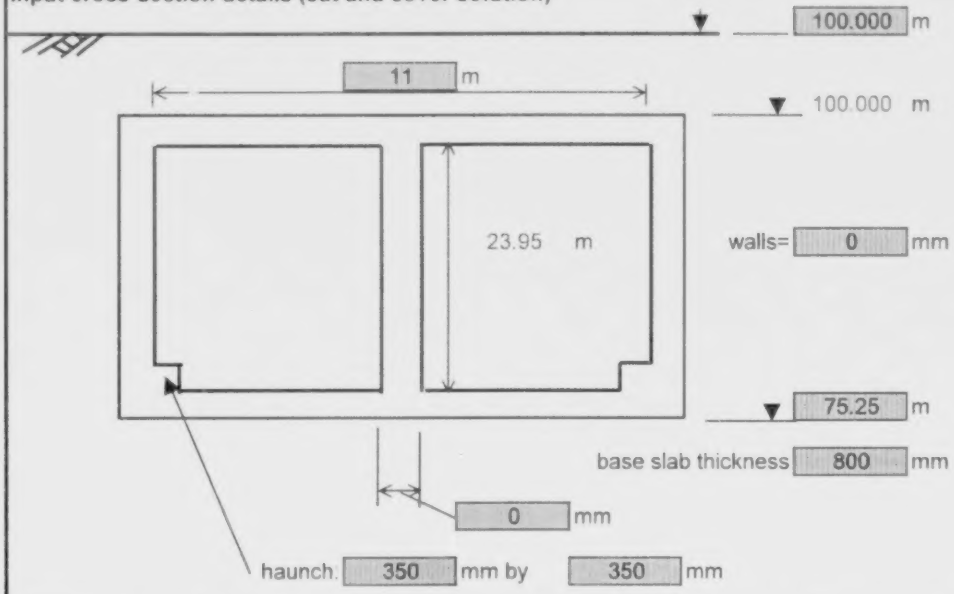
Section Cut and Cover
Length of section: 150 m **Section 5**

Input cross-section details (cut and cover solution)



100.000 m
11 m
100.000 m
23.95 m
walls= 0 mm
75.25 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	40837.5	m3	
concrete=	1356.75	m3	
rebar=	162.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	7185	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	7425.0	m2	
backfill=	0	m3	
surface reinstatement=	1650	m2	

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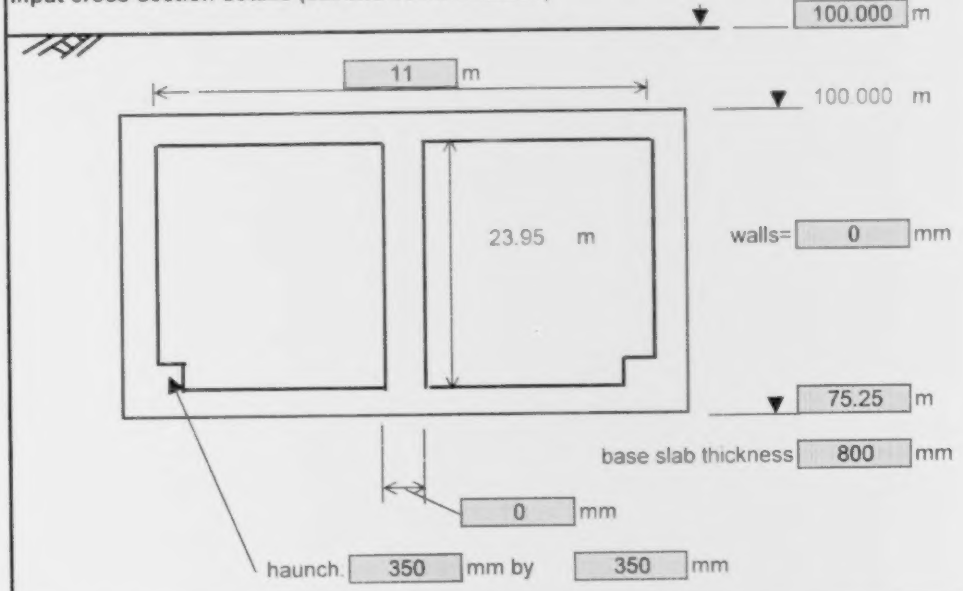
Section Cut and Cover
Length of section: 150 m
Section 5

Input cross-section details (cut and cover solution)



100.000 m
11 m
100.000 m
23.95 m
walls= 0 mm
75.25 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	40837.5	m3	
concrete=	1356.75	m3	
rebar=	162.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	7185	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	7425.0	m2	
backfill=	0	m3	
surface reinstatement=	1650	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	40837.5	60	2450250
concrete	m3	1356.75	190.0	257782.5
rebar	tonnes	162.8	1600	260496
formwork/falsework	m2	7185	140	1005900
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	7425.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	1650	30	49500
			Total	4023929

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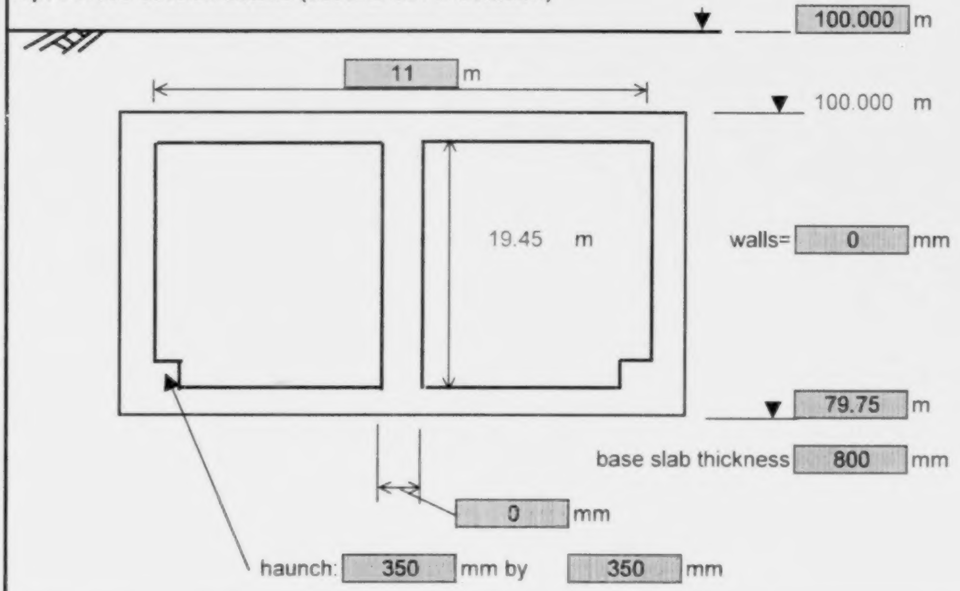
Section Cut and Cover
Length of section: 150 m **Section 6**

Input cross-section details (cut and cover solution)


100.000 m
11 m
100.000 m
19.45 m
walls= 0 mm
79.75 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	33412.5	m3	
concrete=	1356.75	m3	
rebar=	162.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	5835	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	6075.0	m2	
backfill=	0	m3	
surface reinstatement=	1650	m2	

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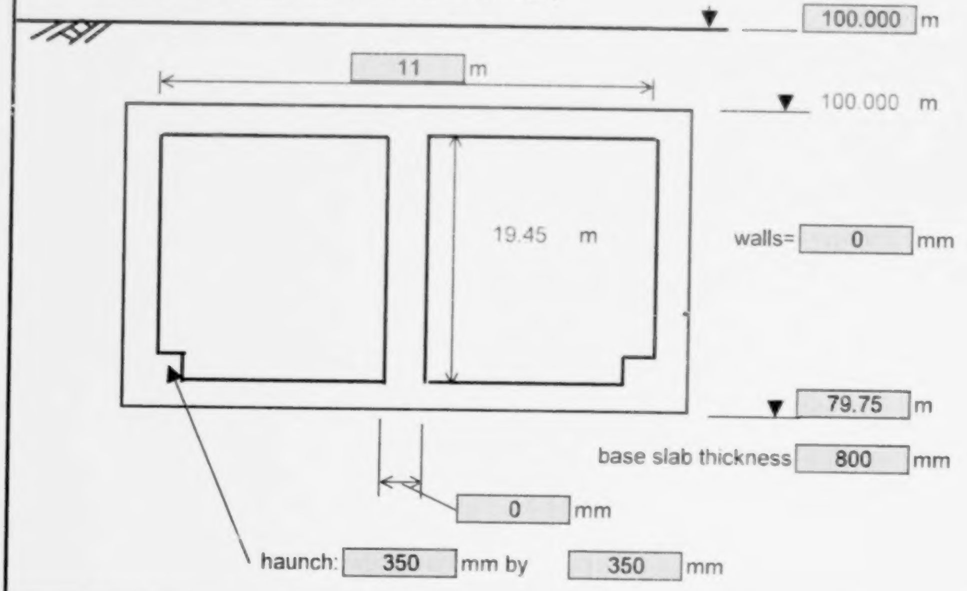
Section Cut and Cover
Length of section: 150 m
Section 6

Input cross-section details (cut and cover solution)



walls= 0 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	33412.5	m3	
concrete=	1356.75	m3	
rebar=	162.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	5835	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	6075.0	m2	
backfill=	0	m3	
surface reinstatement=	1650	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	33412.5	60	2004750
concrete	m3	1356.75	190.0	257782.5
rebar	tonnes	162.8	1600	260496
formwork/falsework	m2	5835	140	816900
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	6075.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	1650	30	49500
			Total	3389429

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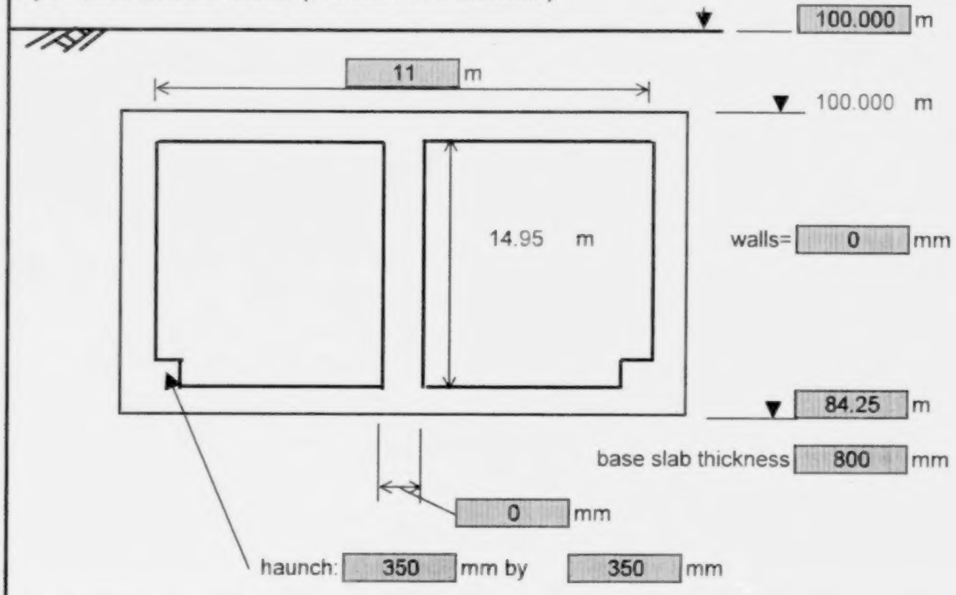
Section Cut and Cover
Length of section: 150 m

Section 7

Input cross-section details (cut and cover solution)


100.000 m
11 m
100.000 m
14.95 m
walls= 0 mm
84.25 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	25987.5	m3	
concrete=	1356.75	m3	
rebar=	162.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	4485	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	4725.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	1650	m2	

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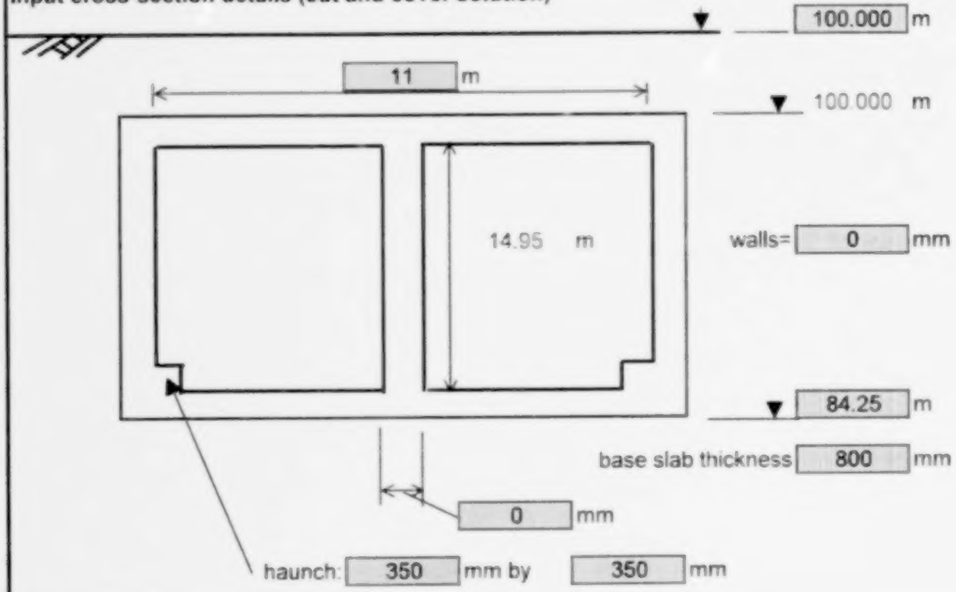
Section Cut and Cover
Length of section: 150 m **Section** 7

Input cross-section details (cut and cover solution)



walls= 0 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	25987.5	m3	
concrete=	1356.75	m3	
rebar=	162.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	4485	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	4725.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	1650	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	25987.5	60	1559250
concrete	m3	1356.75	190.0	257782.5
rebar	tonnes	162.8	1600	260496
formwork/falsework	m2	4485	140	627900
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	4725.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	1650	30	49500
			Total	2754929

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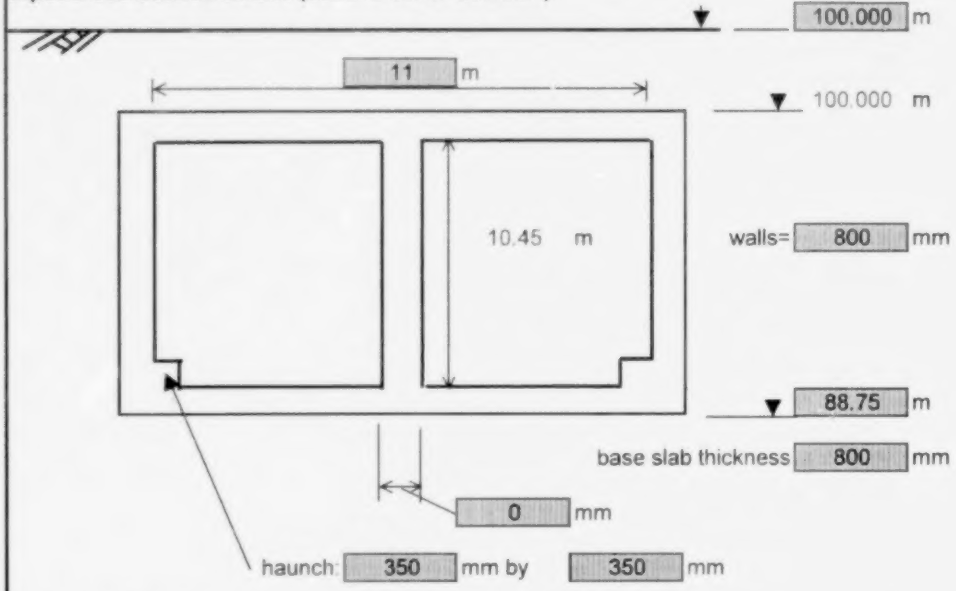
Section Cut and Cover
Length of section: 150 m **Section 8**

Input cross-section details (cut and cover solution)


100.000 m
11 m
100.000 m
10.45 m
walls= 800 mm
88.75 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	21262.5	m3	
concrete=	4056.75	m3	
rebar=	486.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	3135	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	3375.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	1890	m2	

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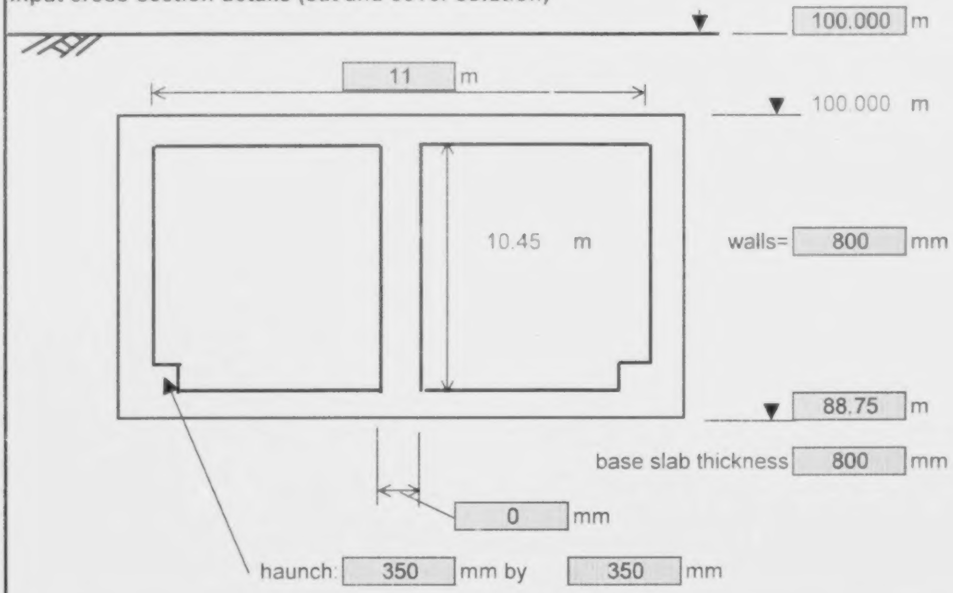
Section Cut and Cover
Length of section: 150 m **Section 8**

Input cross-section details (cut and cover solution)



100.000 m
11 m
100.000 m
10.45 m
walls= 800 mm
88.75 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	21262.5	m3	
concrete=	4056.75	m3	
rebar=	486.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	3135	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	3375.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	1890	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	21262.5	60	1275750
concrete	m3	4056.75	190.0	770782.5
rebar	tonnes	486.8	1600	778896
formwork/falsework	m2	3135	140	438900
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	3375.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	1890	30	56700
			Total	3321029

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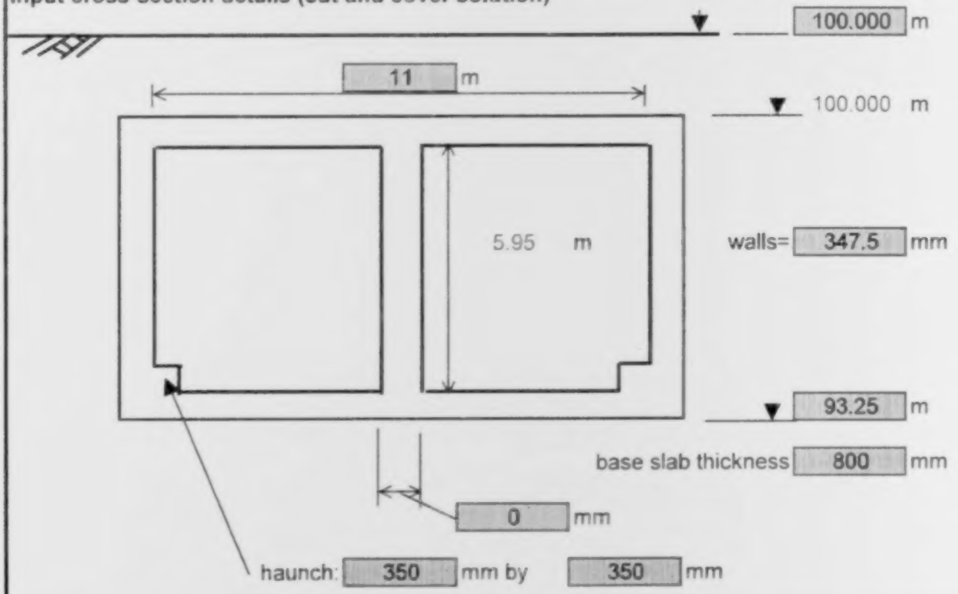
Section Cut and Cover
Length of section: 150 m
Section 9

Input cross-section details (cut and cover solution)


100.000 m
11 m
100.000 m
5.95 m
walls= 347.5 mm
93.25 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	11841.2	m3	
concrete=	2060.438	m3	
rebar=	247.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1785	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	2025.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	1754.25	m2	

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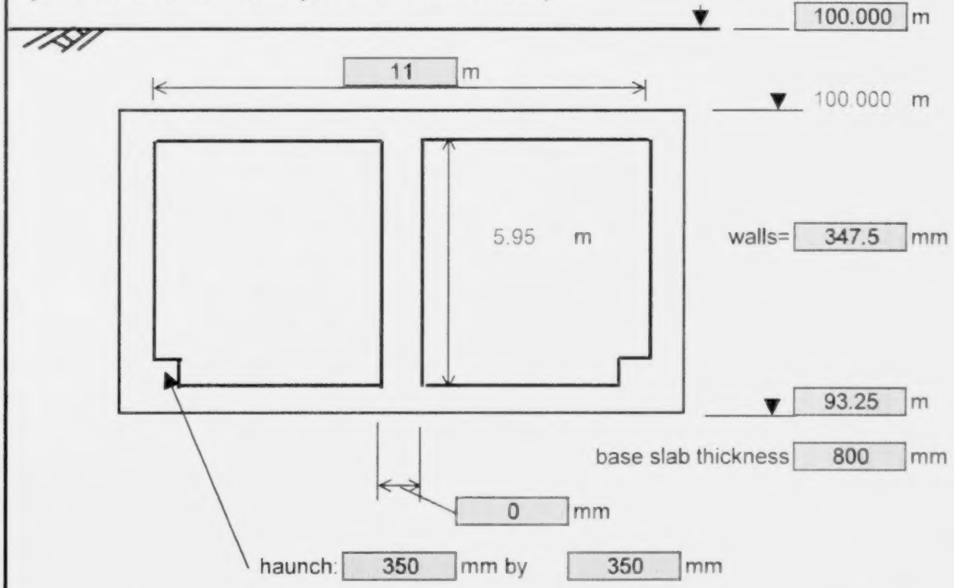
Section Cut and Cover
Length of section: 150 m **Section** **9**

Input cross-section details (cut and cover solution)


100.000 m
11 m
100.000 m
5.95 m
walls= 347.5 mm
93.25 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	11841.2	m3	
concrete=	2060.438	m3	
rebar=	247.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1785	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	2025.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	1754.25	m2	

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Calculated costs

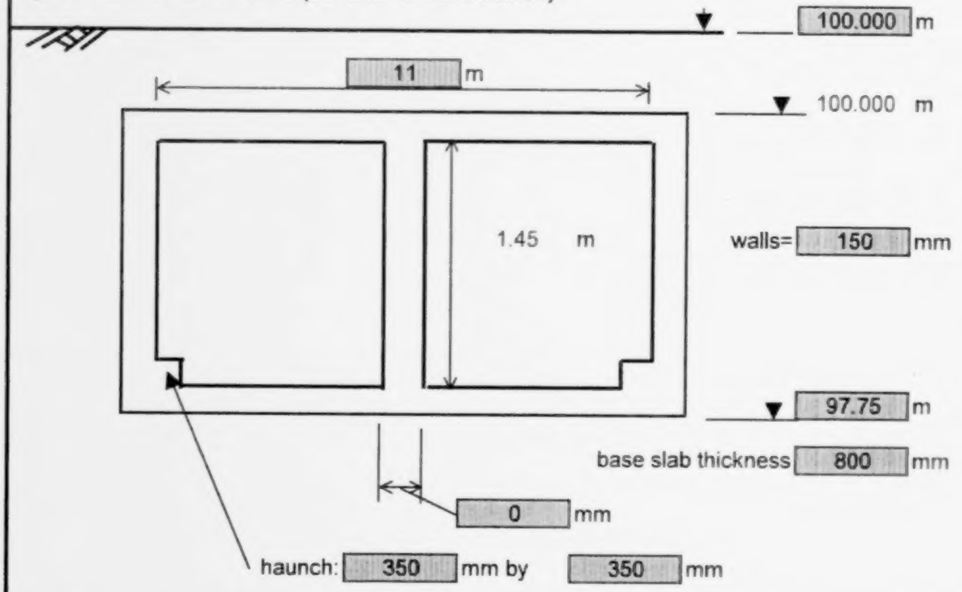
Item	Unit	Quantity	Rate	Cost
excavation	m3	11841.2	60	710471.3
concrete	m3	2060.438	190.0	391483.1
rebar	tonnes	247.3	1600	395604
formwork/falsework	m2	1785	140	249900
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	2025.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	1754.25	30	52627.5
			Total	1800086

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 150 m
Section **10**

Input cross-section details (cut and cover solution)



100.000 m
11 m
100.000 m
1.45 m
walls= 150 mm
97.75 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	3813.8	m3	
concrete=	1458	m3	
rebar=	175.0	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	435	m2	
SP&L<=4.6m deep	675.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	1695	m2	

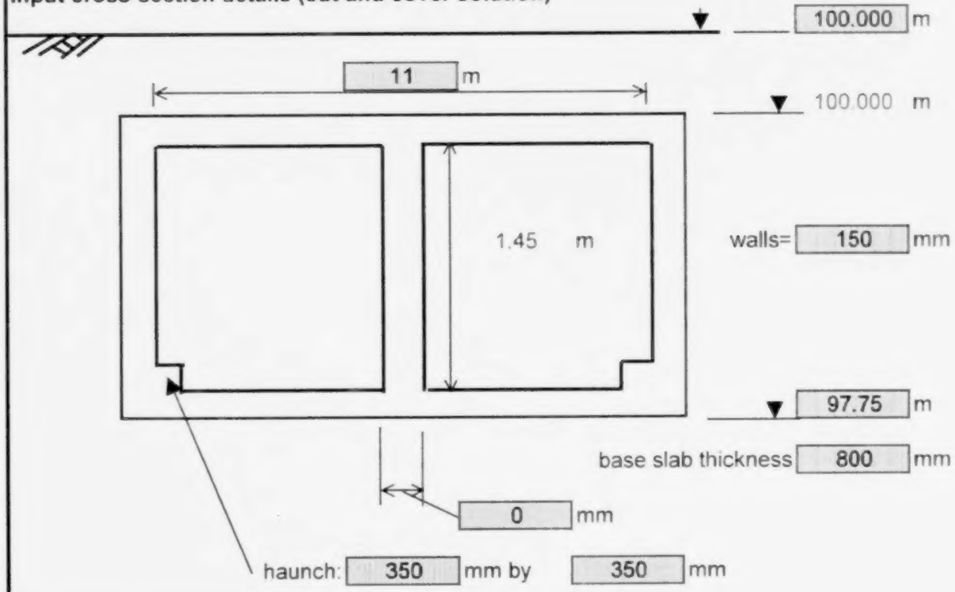
Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 150 m

Section **10**

Input cross-section details (cut and cover solution)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11 m
100.000 m
1.45 m
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97.75 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

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concrete=	1458	m3	
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formwork/falsework=	435	m2	
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10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	1695	m2	

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
Bored Highway Tunnel	**Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	3813.8	60	228825
concrete	m3	1458	190.0	277020
rebar	tonnes	175.0	1600	279936
formwork/falsework	m2	435	140	60900
SP&L<=4.6m deep	m2	675.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	1695	30	50850
			Total	897531

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel

Summary of Costs

Markup for adjacent 0 %

Section	**Cost**
1	11671814
2	10500284
3	5292929
4	4658429
5	4023929
6	3389429
7	2754929
8	3321029
9	1800086
10	897531
Sub-total	39536811

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel

Summary of Costs

Markup for adjacent 0 %

Section	**Cost**
1	11671814
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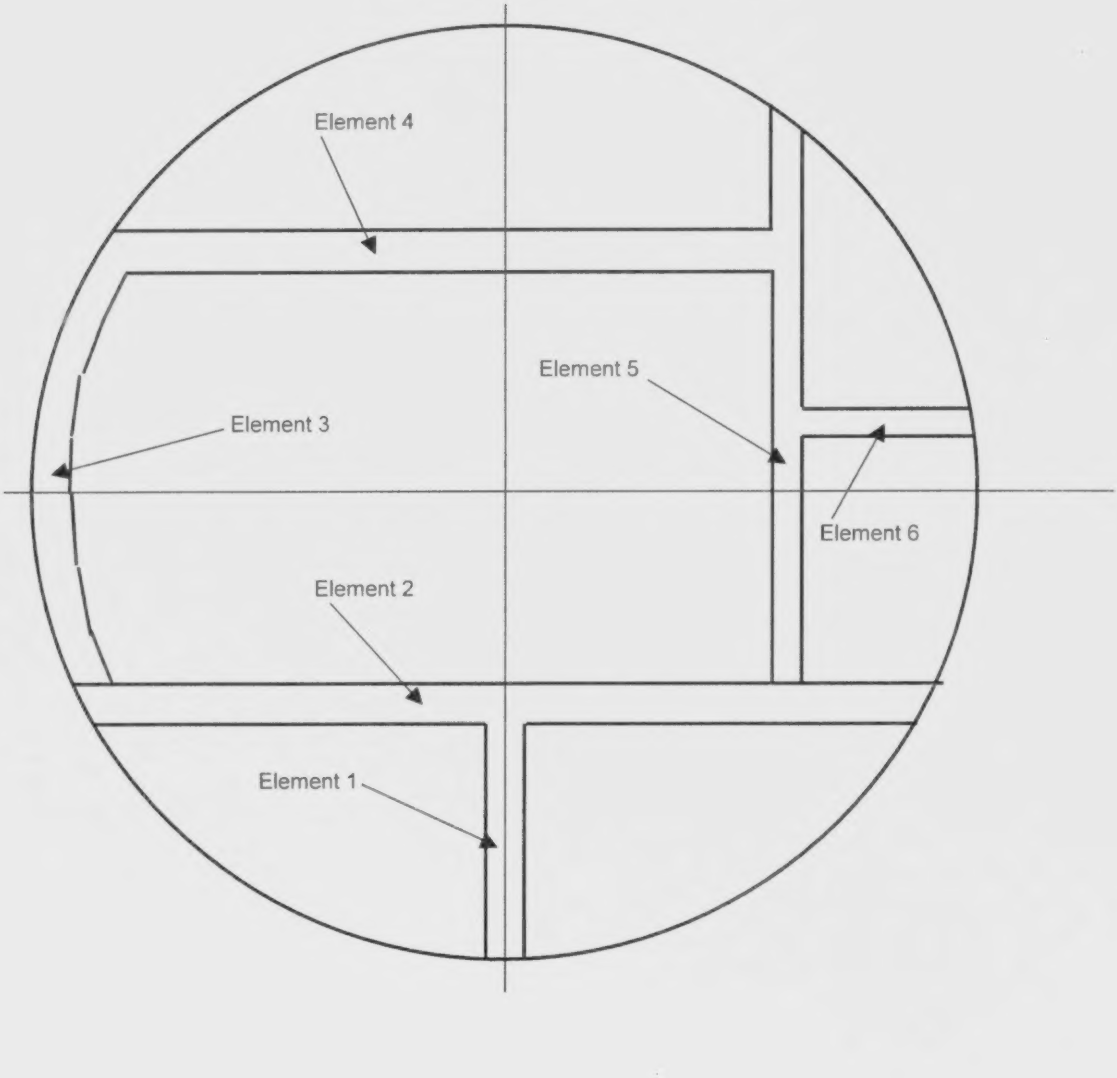
10	897531
Sub-total	39536811

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Lane Bored Highway Tunnel
Tunnel Structural Finishes

Page 1 of 2
Date: June 07, 2004
Calculation by: A.White

Tunnel length= 20248 m


Element 4
Element 5
Element 3
Element 6
Element 2
Element 1

Assumed tunnel cross section

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Lane Bored Highway Tunnel
Tunnel Structural Finishes

Page 2 of 2
Date: June 07, 2004
Calculation by: A.White

Quantity Take-off

Concrete

Element	Nr.	L(m)	b(m)	d(m)	Concrete Qty(m3)	Rebar Qty(m3)
1	1	20248	0.5	2.5	25310	3037.2
2	1	20248	9.4	0.5	95166	11419.9
3	1	20248	0.3	4.8	29157	3498.9
4	1	20248	7.5	0.5	75930	9111.6
5	1	20248	0.3	6.6	40091	4810.9
6	1	20248	2.1	0.3	12756	1530.7
					278410 m3	21989 t

Formwork/falsework

Element	Nr.	L(m)	d(m)	Faces	Area(m2)
1	1	20248	2.5	2	101240
2	2	20248	8.5	1	172108
3	1	20248	4.8	1	97190.4
4	2	20248	7	1	141736
5	2	20248	6.6	2	267273.6
6	1	20248	2.1	1	42520.8
					822068.8 m2

Rates

Concrete	m3	190
Formwork	m2	140
Reinforcement	t	1600

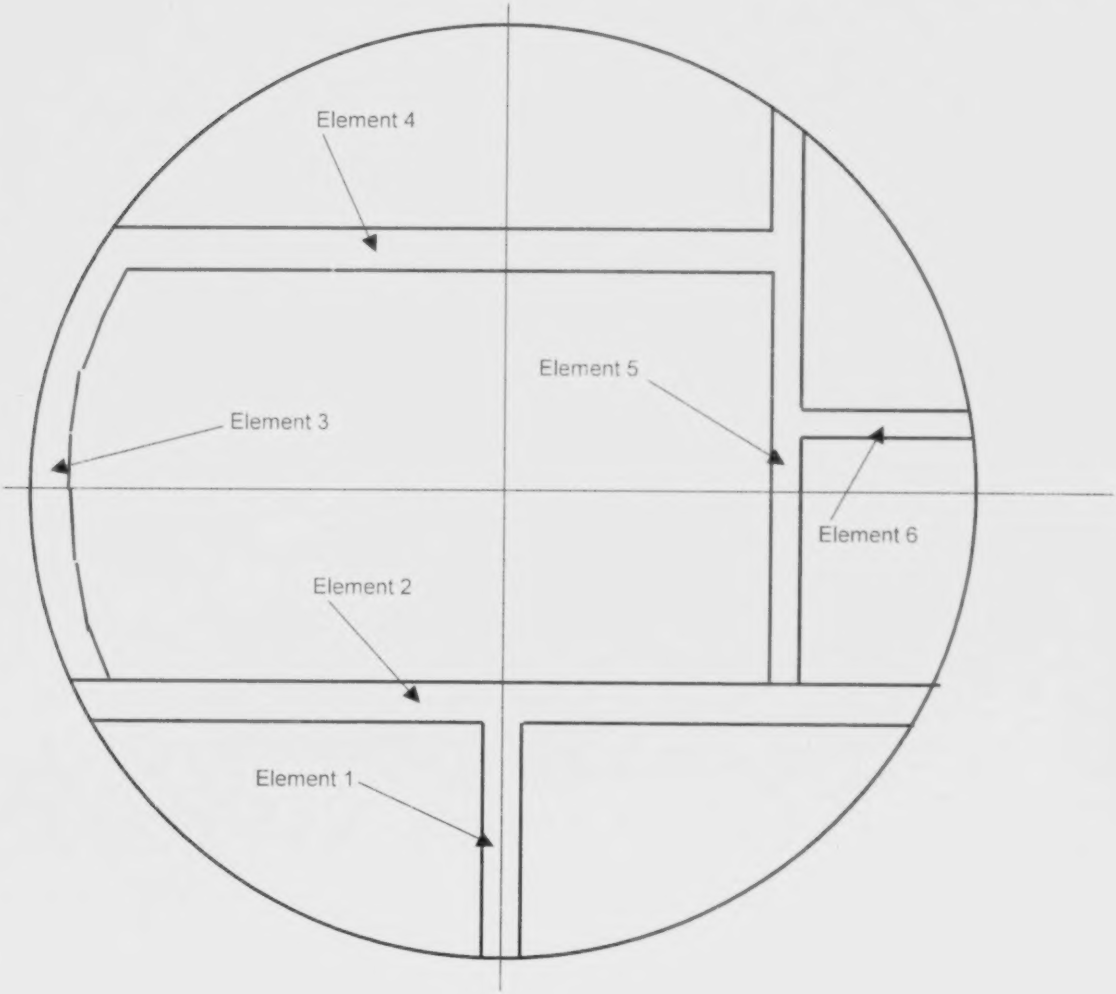
Costs

Concrete	m3	278410 m3	at	190	=	52,897,900
Formwork	m2	822069 m2	at	140	=	115,089,632
Reinforcement	t	21989 t	at	1600	=	35,182,925
					$	203,170,457

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Lane Bored Highway Tunnel
Tunnel Structural Finishes

Page 1 of 2
Date: June 07, 2004
Calculation by: A White

Tunnel length= 20248 m


Element 4
Element 5
Element 3
Element 6
Element 2
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Assumed tunnel cross section

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Reinforcement	t	21989 t	at	1600	=	35,182,925
					$	203,170,457

Main Electrical Components for Novaroute
Newfoundland Fixed Link
Single TBM Bored Highway Tunnel Option

Length of each tunnel= 19991 m Number of tunnels= 1
Tunnel width= 9.5 m

Item	Component	Unit	Qty	Unit Cost	Total Cost	
	Lighting					
	Threshold + transition (1st 700m)	m2	7280	315	2293200	Lighting costed elsewhere
	Interior (balance)	m2	183264.5	120.00	21991740	
				Lighting subtotal	0	
	Substations, generators, UPS					
	Substations	Ea	2	1337000	2674000	
	Emergency generator	Ea	1	955000	955000	
	UPS (Battery system)	Ea	1	573000	573000	
				Substations, generators, UPS subtotal	4202000	
	CCTV system					
	Cameras (every 60m)	Each	333	3100	1032300	
	Control station	Each	1	30000	30000	
				CCTV system subtotal	1062300	
	Provide power for gas detection, ventilation etc.					
	Power provision	m	19991	45	899595	
				Power subtotal	899595	
	Lane control system					
	Fibre optic display (every 200m)	Each	99	12500	0	
				Lane control system subtotal	0	

Total Electrical 6163895

Newfoundland Fixed Link
Pre-feasibility Study
TBM Bored Highway Tunnel Option
Tunnel Lighting Costs

Fraser River Project - 2x3 lane tunnels

For 1550 m length of Theo Van Kooten calculated the tunnel lighting cost as follows:

732	m of threshold lighting costs $	661231.22	1260	lights		
818	m of interior lighting costs $	73151.75	139	lights		
1550	m of nightime circuit costs $	126767.31	241	lights		
1640	lights cost $	117280.47	to instal			
1550	m of conduit costs	101424.99				
		1079855.74	*	2	= $	2,159,711

Prorating for Newfoundland - assuming *50% for single lane tunnel

for 19991 m length of tunnel

732	m of threshold lighting costs $	661231.22	1260	lights		
19259	m of interior lighting costs $	1722285.5	3273	lights		
19991	m of nightime circuit costs $	1634971.16	3109	lights		
7642	lights cost $	546498.39	to instal			
19991	m of conduit costs	1308120.63				
		5873106.91	*	0.5	= $	2,936,553

Main Electrical Components for Novaroute
Newfoundland Fixed Link
Single TBM Bored Highway Tunnel Option

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Tunnel width= 9.5 m

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	Interior (balance)	m2	183264.5	120.00	21991740
	Lighting subtotal				0
	Substations, generators, UPS				
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	Control station	Each	1	30000	30000
	CCTV system subtotal				1062300
	Provide power for gas detection, ventilation etc.				
	Power provision	m	19991	45	899595
	Power subtotal				899595
	Lane control system				
	Fibre optic display (every 200m)	Each	99	12500	0
	Lane control system subtotal				0

Lighting costed elsewhere

Total Electrical 6163895

Newfoundland Fixed Link
Pre-feasibility Study
TBM Bored Highway Tunnel Option
Tunnel Lighting Costs

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Newfoundland Fixed Link Pre-feasibility Study
TBM Bored Highway Tunnel - North Vent Adit
Tunnel Final Liner Cost Estimate

Tunnel length= 600 m
Liner cross section area= 5.47 m2

Shift pattern

Shifts	Hours	Days
3	8	5

Advance rate= 30 m/day

Rebar ratio= 0.12 t/m3 of concrete

Concrete supply=$ 135 /m3

Rebar supply=$ 900 /t

Initial form set-up time= 4 weeks

Durations

Number of days= 40 days
Number of hours= 960 hours
Number of weeks= 8 weeks

Labour

Crew size 15
Average labour rate $ 47 /hour

Total labour cost=$ 676,800

Equipment

Form $ 1000000
Weekly cost of other equipment $ 15000 (see TED 2370)

Total equipment cost=$ 1,120,000

Materials

Concrete= 3279.8227 m3
Rebar= 393.57873

Concrete cost=$ 442,776
Rebar cost=$ 354,221

Total material cost=$ 796,997

Cost Summary

Labour	676,800
Equipment	1,120,000
Materials	796,997
Total	**2,593,797**

Newfoundland Fixed Link Pre-feasibility Study
TBM Bored Highway Tunnel - North Vent Adit
Tunnel Drill and Blast Cost Estimate

Drill & blast excavation @ $ 250 /m3

Tunnel length= 600 m
Tunnel excavated diameter= 6.5 m

Excavated volume= 19909.8 m3

Excavation cost=$ 4,977,461

Newfoundland Fixed Link Pre-feasibility Study
TBM Bored Highway Tunnel - North Vent Adit
Tunnel Final Liner Cost Estimate

Tunnel length= 600 m
Liner cross section area= 5.47 m2

Shift pattern

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Newfoundland Fixed Link Pre-feasibility Study
TBM Bored Highway Tunnel - North Vent Adit Shaft
Tunnel Drill and Blast Cost Estimate

shaft excavated diameter= 5.5 m
depth= 100 m
shaft final diameter= 6.1 m

From graph

unlined shaft cost=$ 17000 /m

Quantities

Concrete Base= 24 m3
Shotcrete= 173 m3
Rockbolts= 1728 m2
final cast in place liner= 547 m3

Direct Costs

				$ - Cost	
shaft excavation etc.	100	*	17000	1700000	
Concrete Base	24	*	150	3564	
Shotcrete	173	*	500	86394	
Rockbolts	1728	*	10	17279	
liner	547	*	600	327982	(includes steel & forms)
		Total Direct Cost=		**2135219**	

Newfoundland Fixed Link Pre-feasibility Study
TBM Bored Highway Tunnel - North Vent Adit Shaft
Tunnel Drill and Blast Cost Estimate

shaft excavated diameter= 5.5 m
depth= 100 m
shaft final diameter= 6.1 m

From graph

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Quantities

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Shotcrete=	173	m3
Rockbolts=	1728	m2
final cast in place liner=	547	m3

Direct Costs

				$ - Cost	
shaft excavation etc.	100	*	17000	1700000	
Concrete Base	24	*	150	3564	
Shotcrete	173	*	500	86394	
Rockbolts	1728	*	10	17279	
liner	547	*	600	327982	(includes steel & forms)
		Total Direct Cost=		**2135219**	

Newfoundland Fixed Link Pre-feasibility Study
TBM Bored Highway Tunnel
TBM Bored Option - North Vent Adit

D&B Excavation	4,977,461
Liner	2,593,797
Shaft	2,135,219
	9,706,476

Newfoundland Fixed Link Pre-feasibility Study
TBM Bored Highway Tunnel - South Vent Adit
Tunnel Final Liner Cost Estimate

Tunnel length= 2000 m
Liner cross section area= 5.47 m2

Shift pattern

Shifts	Hours	Days
3	8	5

Advance rate= 30 m/day

Rebar ratio= 0.12 t/m3 of concrete

Concrete supply=$ 135 /m3

Rebar supply=$ 900 /t

Initial form set-up time= 4 weeks

Durations

Number of days= 87 days
Number of hours= 2080 hours
Number of weeks= 17 weeks

Labour

Crew size 15
Average labour rate $ 47 /hour

Total labour cost=$ 1,466,400

Equipment

Form $ 1000000
Weekly cost of other equipment $ 15000 (see TED 2370)

Total equipment cost=$ 1,260,000

Materials

Concrete= 10932.742 m3
Rebar= 1311.9291

Concrete cost=$ 1,475,920
Rebar cost=$ 1,180,736

Total material cost=$ 2,656,656

Cost Summary

Labour	1,466,400
Equipment	1,260,000
Materials	2,656,656
Total	**5,383,056**

Newfoundland Fixed Link Pre-feasibility Study
TBM Bored Highway Tunnel - South Vent Adit
Tunnel Drill and Blast Cost Estimate

Drill & blast excavation @	$	250	/m3
Tunnel length=	2000	m	
Tunnel excavated diameter=	6.5	m	
Excavated volume=	66366.1	m3	
Excavation cost=$	16,591,536		

Newfoundland Fixed Link Pre-feasibility Study
TBM Bored Highway Tunnel - South Vent Adit
Tunnel Final Liner Cost Estimate

Tunnel length= 2000 m
Liner cross section area= 5.47 m2

Shift pattern

Shifts	Hours	Days
3	8	5

Advance rate= 30 m/day

Rebar ratio= 0.12 t/m3 of concrete

Concrete supply=$ 135 /m3

Rebar supply=$ 900 /t

Initial form set-up time= 4 weeks

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Number of days= 87 days
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Labour	1,466,400
Equipment	1,260,000
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Newfoundland Fixed Link Pre-feasibility Study
TBM Bored Highway Tunnel - South Vent Adit
Tunnel Drill and Blast Cost Estimate

Drill & blast excavation @ $ 250 /m3

Tunnel length= 2000 m
Tunnel excavated diameter= 6.5 m

Excavated volume= 66366.1 m3

Excavation cost=$ 16,591,536

Newfoundland Fixed Link Pre-feasibility Study
TBM Bored Highway Tunnel - South Vent Adit Shaft
Tunnel Drill and Blast Cost Estimate

shaft excavated diameter= 5.5 m
depth= 0 m
shaft final diameter= 6.1 m

From graph

unlined shaft cost=$ 17000 /m

Quantities

Concrete Base= 24 m3
Shotcrete= 0 m3
Rockbolts= 0 m2
final cast in place liner= 0 m3

Direct Costs

				$ - Cost	
shaft excavation etc.	0	*	17000	0	
Concrete Base	24	*	150	3564	
Shotcrete	0	*	500	0	
Rockbolts	0	*	10	0	
liner	0	*	600	0	(includes steel & forms
			Total Direct Cost=	**3564**	

Newfoundland Fixed Link Pre-feasibility Study
TBM Bored Highway Tunnel - South Vent Adit Shaft
Tunnel Drill and Blast Cost Estimate

shaft excavated diameter=	5.5	m
depth=	0	m
shaft final diameter=	6.1	m

From graph

unlined shaft cost=$ 17000 /m

Quantities

Concrete Base=	24	m3
Shotcrete=	0	m3
Rockbolts=	0	m2
final cast in place liner=	0	m3

Direct Costs

				$ - Cost	
shaft excavation etc.	0	*	17000	0	
Concrete Base	24	*	150	3564	
Shotcrete	0	*	500	0	
Rockbolts	0	*	10	0	
liner	0	*	600	0	(includes steel & forms
		Total Direct Cost=		**3564**	

Newfoundland Fixed Link Pre-feasibility Study
TBM Bored Highway Tunnel
TBM Bored Option - South Vent Adit

D&B Excavation	16,591,536
Liner	5,383,056
Shaft	3,564
	21,978,156

Newfoundland Fixed Link Pre-feasibility Study
Tunnel Drainage
Bored Highway Tunnel
Drainage Costs

Calculation by: ANW
Date: Jun.08, 2004

Sump Sizing

Assume inflow to tunnel of 1 litres/m2/24hours

Tunnel length= 21000 m
Tunnel diameter= 11 m

24 hour inflow= 1995697 litres = 1996 m3
assume same again for firefighting= 1996 m3

Required sump capacity= 3991 m3

Assumed sump diameter= 6 m
Assumed number of sump structures= 2 m

Required length of each sump= 71 m

Piping

Assume 300 mm diameter steel pipe connecting each sump to the portal areas
Number of pipes= 1
Assume sumps located at 1/3 and 2/3 of tunnel length

Total length of piping= 14300 m

Rates

Sump construction-$	17795	/m of sump	
Pipe-$	265	/m of pipe	
Pipe installation labour -$	29	/m of pipe	(assume 6 man crew installing 100m/day)
Pipe installation equipment-$	10	/m of pipe	(assume $1000/day for equipment)
Pumps-$	125000	/pump	

Costs

Item	Unit	Qty	Rate	$-Cost
Sump construction	m	142	17795	2,526,890
Pipe	m	14300	265	3,789,500
Pipe installation	m	14300	29	411,840
Equipment	m	14300	10	143,000
Pumps	Nr	4	125000	500,000
			Total	7,371,230

Newfoundland Fixed Link Pre-feasibility Study
Highway Tunnel Options
South Vehicle Holding Area

Area= 300 m by 600 m

Earthworks

Assume 0.5 m depth cleared over entire area

Spoil excavation and removal @ $ 30 /m3

Earthworks= 2,700,000

Surface

Assume surface @ 20 /m2

Surface= 3,600,000

Buildings etc.

Public facilities building @	80000	See CJT estimate
Site maintenance building @	220000	See CJT estimate
Fire engines @	360000	See CJT estimate

Total cost **6,960,000**

Newfoundland Fixed Link Pre-feasibility Study
Tunnel Drainage
Bored Highway Tunnel
Drainage Costs

Page 1 of 1
Calculation by: ANW
Date: Jun.08, 2004

Sump Sizing

Assume inflow to tunnel of 1 litres/m2/24hours

Tunnel length= 21000 m
Tunnel diameter= 11 m

24 hour inflow= 1995697 litres = 1996 m3
assume same again for firefighting= 1996 m3

Required sump capacity= 3991 m3

Assumed sump diameter= 6 m
Assumed number of sump structures= 2 m

Required length of each sump= 71 m

Piping

Assume 300 mm diameter steel pipe connecting each sump to the portal areas
Number of pipes= 1
Assume sumps located at 1/3 and 2/3 of tunnel length

Total length of piping= 14300 m

Rates

Sump construction-$ 17795 /m of sump
Pipe-$ 265 /m of pipe
Pipe installation labour -$ 29 /m of pipe (assume 6 man crew installing 100m/day)
Pipe installation equipment-$ 10 /m of pipe (assume $1000/day for equipment)
Pumps-$ 125000 /pump

Costs

Item	**Unit**	**Qty**	**Rate**	**$-Cost**
Sump construction	m	142	17795	2,526,890
Pipe	m	14300	265	3,789,500
Pipe installation	m	14300	29	411,840
Equipment	m	14300	10	143,000
Pumps	Nr	4	125000	500,000
			Total	7,371,230

Newfoundland Fixed Link Pre-feasibility Study
Highway Tunnel Options
South Vehicle Holding Area

Area= 300 m by 600 m

Earthworks

Assume 0.5 m depth cleared over entire area

Spoil excavation and removal @ $ 30 /m3

Earthworks= 2,700,000

Surface

Assume surface @ 20 /m2

Surface= 3,600,000

Buildings etc.

Public facilities building @	80000	See CJT estimate
Site maintenance building @	220000	See CJT estimate
Fire engines @	360000	See CJT estimate

Total cost **6,960,000**

Newfoundland Fixed Link Pre-feasibility Study
South Vehicle Holding Area

Area= 300 m by 600 m

Earthworks

Assume 0 m depth cleared over entire area

Spoil excavation and removal @ $ 30 /m3

Earthworks= 0

Surface

Assume surface @ 20 /m2

Surface= 3,600,000

Buildings etc.

Public facilities building @ 80000 See CJT estimate
Site maintenance building @ 220000 See CJT estimate
Fire engines @ 360000 See CJT estimate

Total cost **4,260,000**

Newfoundland Fixed Link Pre-feasibility Study
South Vehicle Holding Area

Area= 300 m by 600 m

Earthworks

Assume 0 m depth cleared over entire area

Spoil excavation and removal @ $ 30 /m3

Earthworks= 0

Surface

Assume surface @ 20 /m2

Surface= 3,600,000

Buildings etc.

Public facilities building @	80000	See CJT estimate
Site maintenance building @	220000	See CJT estimate
Fire engines @	360000	See CJT estimate

Total cost **4,260,000**

APPENDIX D (2)

DRILL & BLAST HIGHWAY TUNNEL COSTS

Hatch Mott MacDonald

Newfoundland Fixed Link Pre-feasibility - Drill & Blast Highway Tunnel - Cost Summary

BORED TUNNEL CONSTRUCTION COSTS

ITEM	UNIT	MAIN TUNNEL
MOBILIZATION & DEMOBILIZATION	LS	8,000,000
DRILL & BLAST TUNNELLING	LS	461,565,738
TUNNEL LINER	LS	152,191,081
TUNNEL FINISHES	LS	123,215,724
NORTH APPROACH STRUCTURES	LS	10,607,127
SOUTH APPROACH STRUCTURES	LS	6,036,419
NORTH VENTILATION ADIT	LS	9,706,476
SOUTH VENTILATION ADIT	LS	21,978,156
ROAD FINISHES	LS	2,646,625
TUNNEL DRAINAGE	LS	7,370,000
NORTH VEHICLE HOLDING AREA	LS	6,960,000
SOUTH VEHICLE HOLDING AREA	LS	4,260,000
UTILITY DIVERSIONS	LS	1,000,000
MONITORING	LS	1,000,000
SUBTOTAL CIVIL		**$816,537,346**
CIVIL CONTINGENCIES		
CONTINGENCY	40%	$326,614,939
TOTAL CIVIL		**$1,143,152,285**
M&E AND FINISHING WORK		
VENTILATION EQUIPMENT	LS	$6,000,000
VENTILATION BUILDINGS x 2	LS	$2,000,000
FIRE SUPPRESSION SYSTEM	LS	$4,000,000
CONTROL CENTRE	LS	$4,000,000
SIGNALLING	LS	$0
LIGHTING	LS	$2,969,966
CCTV SYSTEM	LS	$1,074,700
GAS DETECTION	LS	$911,160
SUBSTATION, GENERATORS, UPS	LS	$4,202,000
SUBTOTAL M&E AND FINISHING		**$25,157,826**
CONTINGENCIES	20%	$5,031,565
TOTAL M&E AND FINISHING		**$30,189,392**
TOTAL CIVIL, M&E AND FINISHING		**$1,173,341,676**
ALLOWANCES		
CONTRACTOR OH	15%	$176,001,251
CONTRACTOR PROFIT	15%	$176,001,251
CONSTRUCTION TOTAL		**$1,526,000,000**
PRE-CONSTRUCTION AND SUPERVISION		
FEASIBILITY STUDY	LS	$11,000,000
ENVIRONMENTAL ASSESSMENT	LS	$4,000,000
DESIGN	5%	$76,300,000
CONSTRUCTION MANAGEMENT	10%	$152,600,000
OWNERS COSTS	2%	$30,520,000
PRE-CONSTRUCTION TOTAL		$274,420,000
GRAND TOTAL		**$1,800,420,000**

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Project:	Newfoundland Fixed Link Study	**Project Number:**	213789
Estimate Description:	Prefeasibility Level		
		Project Phase:	Prefeasibility Design
		Estimate Date:	June 11 2004

Newfoundland Fixed Link Study

Prefeasibility Level

213789

Prefeasibility Design

June 11 2004

STRUCTION AND SUPERVISION

Detailed Cost Estimate Report

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Version VANC-1.5

P:\MEMORIAL\213789\DES\C Cost Estimating & Scheduling\[illegible] June 11 2004.xls]V-317

Project:	**Newfoundland Fixed Link Study**	**Project Number:**	213789
Estimate Description:	Prefeasibility Level	**Parent Estimate ID:**	V-300
Tunnel Name:	Highway Tunnel - Single Lane - Down Drive	**Project Phase:**	Prefeasibility Design
Construction Activity:	Excavation (Drill & Blast) & Initial Support	**Geology Type:**	Poor to Fair Sediments & Volcanics
Estimate Definition ID:	V-317	**Estimate Date:**	June 11 2004

Tunnel Characteristics

Tunnel Length:	6,500.0		m
Design Width:	10.9		m
Design Wall Height (Ave.)	4.5		m
Design Wall to Roof:	3.7		
Design Max Height :	8.2		m
Ave Tunnel Overbreak:	20.0		cm
Tunnel Face Area:	86.8	(Includes Overbreak)	m^2
Crown Perimeter:	15.1	(Includes Overbreak)	m
Wall & Crown Perimeter:	24.5	(Includes Overbreak)	m
Wall & Crown Area:	159,433	(Includes Overbreak)	m^2
Neat Tunnel Excav. Vol.:	564,086	(Includes Overbreak)	m^3
Re-Muck / Pull-Out Bays:			
Bay Length:	10.0		m
Spacing Bttn Bays:	1000.0		m
Number of Bays:	6		No
Total Length of Bays:	60.0		m
Neat Excavation Vol.:	5,207		m^3
Total Tunnel Volume:	569,293		m^3
Muck Bulking Factor:	1.6		Ratio
Bulked Tunnel Volume:	910,869	(Loose Muck Volume)	m^3

Primary Mucking Production Details

(Activity to remove blast muck from face to conveyor & muck cars)

Muck Volume / Blast:	458.2		m^3
Mucking Volume / Trip:	5.00		m^3
Bucket Fill Factor (%):	90.0		%
Number of Trips:	102		No
Ave. Dist. to Load:	35.0	(Ave Distance One Way)	m
Ave. Tramming Speed:	8.0		km/hr
Load, Dump, Manoever:	1.0	(Time per Trip)	Min
Face Cleanup / Blast:	15.0		Min
Mucking Time:	2.8		Hours
Mucking Rate:	161.5		m^3 / Hour

Tunnel Support Class Details

Class I - No Support:	0.0	(%)	0	(m)
Class II - Spot Bolts:	0.0	(%)	0	(m)
Class III - Crown Only:	40.0	(%)	2,600	(m)
Class IV - Full Pattern:	50.0	(%)	3,250	(m)
Class V - Steel Sets:	10.0	(%)	650	(m)
Total	100.0		6,500	(m)

Initial Shotcrete Support Details

Support Arc Length:	24.5		m
Thickness:	25.0		mm
Volume / Round:	2.3		m^3
Time:	0.8	(Includes Scaling & Equip Set-up)	Hours

Shift Details

Shift Arrangement:	3.0	Shifts / Day
	8.0	Hours / Shift
	7.0	Days / Week

Drill, Charge, Blast, Vent & Mucking Details

Survey Tunnel / Holes / Map:	30.0	Min / Cycle
Drilling Blast Holes:		
Hole Length:	3.9	m / Hole
Perim. Blast Hole Spacing:	0.50	m
Interior Blast Hole Spacing:	1.25	m
No. Perimeter Holes:	49	No
No. Interior Area Holes:	55.5	No
No. Blast Initiation Holes:	15	No
Number of Drillholes / Blast:	120	Blastholes / Blast
Blast Hole / Face Area Ratio:	1.38	Holes / m^2
Typical / Check Ratio:	1.26	Holes / m^2
Drill Eqpt Set-Up Time:	40	min / Set-up
Drill Penetration Rate:	0.30	m / Min
	18	m/hour
# of Drills or Booms:	6.0	No
Charging & Blasting:		
Prime & Load Rate / Hole:	2.50	min / Blasthole
Prep & Hook-up Time:	40.0	min / Set-up
Total No. Blasts / Tunnel:	1988	No
Net Blast Break Length:	3.3	m / Blast
Blast & Ventilation Time:	1.0	Hours

Pre-Excavation Grouting Details

% Tunnel to be Grouted:	12.0	%
Tunnel Length to Grout:	780	m
Grout Hole Length:	7.0	m
No. of Grouting Applications:	111	No
Perim. Grout Holes Spacing:	1.50	m
# Perim. Grout Holes:	16	Holes / Grout Cycle
Drilling Penetration Rate:	50	m/hour
No. of Drill Booms:	2	No
Drilling Time per Cycle:	128	Min
Grout Eqpt. Set-Up Time:	1.0	Hours / Grout Cycle
No. of Holes Grouted at Once:	2	Hoses
Grouting Injection Rate:	10	min / Drillhole
Full Grout Cycle Time:	66.0	Hours

Steel Set Installation Details

Steel Set Spacing:	1.0	m
Total No. Sets / Tunnel:	650	No
Ave. Installation Time / Set:	3.0	Hours
Total Installation Time:	1,950	Hours

Estimated by ____PJP_____
Checked by ____________

Wiremesh Installation Details

Install Rate:	100	m^2 / Hour
Total Install Time:	1,757.7	Hours
Ave. Install Time:	53.1	Min
Overlap:	5	%
Net Applied Area:	159,433 (Assume Class V only)	m^2
Area with Overlap:	175,775	m^2

Final Shotcrete Support Class Details

Shotcrete Thickness:		
Classes I and II:	0	mm
Class III:	0	mm
Classes IV:	50	mm
Class V:	100	mm
Support Arc Length:		
Class I:	0.0	m
Class II:	0.0	m
Class III:	0.0	m
Class IV:	24.5	m
Class V:	24.5	m

Initial and Final Shotcrete Application Details

Net Volume:	5,580		m^3
Rebound / Waste:	15		%
Final Layer Volume:	6,417		m^3
No. of Applications:	1142	(Required Per Bench)	No.
Ave. Vol. / Application:	5.6		m^3
Surface Prep Time:	10.0		Min
Total Surface Prep Time:	11,424		Min
Application Rate:	24.0		m^3 / Hour
Total Application Time:	16,043		Min
Eqpt. Setup Time:	20.0		Min
Total Setup Time:	22,848		Min
Eqpt. Remove Time:	10.0	(Required Per Application)	Min
Total Remove Time:	11,424		Min
Total Shotcreting Time:	61,740	(For Final Shotcrete Layer)	Min
Equivalent Time / Blast:	31.1		Min / Cycle

Secondary Mucking Details

Req'd during Tunneling:	No	(No if loaded directly into trucks in tunnel)	
Ave. LHD Tram Speed:	0.0		km / hour

Wick Drain Installation Details

Drain Spacing:	0.0	m
Installation Time / Row:	0.0	Hours / Drain

Average Tunneling Productivity Cycle Details

Equiv. Pre-Exc. Grouting:	3.7		Hours
Drilling:	5.0		Hours
Charging:	5.7		Hours
Blast & Venting:	1.0		Hours
Mucking:	2.8		Hours
Scaling:	0.3		Hours
Surveying / Mapping:	0.5		Hours
Initial Shotcreting:	0.8		Hours
Install Services:	0.5	(Equiv. Time Per Cycle)	Hours
Non-Productive Time:	0.5	(Travel in/out, Break)	Hours
Include Rockbolting:	Yes	(Yes / No, as part of Cycle Time)	
If yes, % of Support Rq'd:	30	(% Req'd During Cycle for Poorer Ground)	
Rockbolting:	0.5		Hours
Total Cycle Time:	21.3		Hours

Rockbolt Support Class Details

	(Bolts Per Row)	(Bolts Per m)	(Bolts Per Support Class)
Class I:	0	0.0	0
Class II:	0.0	0.0	0
Class III:	9	6.0	15,600
Class IV:	21	14.0	45,500
Class V:	0	0.0	0
Total:			61,100

Face Scaling

Scaling Time:	20.0	min / Blast

Rockbolt Installation Details

Rockbolt Length:	3.0	m
Row Spacing:	1.5	m
No. Rockbolts Required:	61,100	No
Ave. Bolts / Round:	31.0	Bolts / Blast
Drilled Length / Round:	93	m
Total Drilling Length:	183,300	m
Drill Penetration Rate:	1.5	m / Min
# of Drills / Booms Used:	3	No.
Ave. Drilling Time / Round:	20.7	Min
Bolt Install Rate	2.0	Min / Bolt
Ave. Bolt Install Time:	62.0	Min
Drill Set-Up Time:	10.0	Min
Total Bolt Drill/Install Time:	92.7	Min

Drainhole Details

Drainhole Spacing:	3.0	m
Drainhole Length:	1.1	m
Total Area:	79,716.4	m^2
Total Drainholes:	8,857.4	# / Per Tunnel
Total Length:	9,743.1	m

Note: Activity carried out concurrent with other activities

Duration of Tunneling:

Pre-Exc. Grouting Time =	7,349.2	Hours
Drilling Time =	9,932.2	Hours
Charge, Blast, Vent Time =	13,244.3	Hours
Primary Mucking Time =	5,641.7	Hours
Scaling Time =	1,988.2	Hours
Survey / Map Time =	993.9	Hours
Install Steel Sets Time =	1,950.0	Hours
Initial Shotcreting Time =	1,518.0	Hours
Install Services Time =	993.9	Hours
Rockbolting (of % Critical) =	921.6	Hours
Non-Productive Time =	993.9	Hours
Total Time =	45,527.0	Hours
	62.5	Months
(Critical Path Tunneling Activities Only)	271.0	Weeks
	1,897.0	Days

Other Concurrent Tunneling Activities

Rockbolting (of % Not Critical) =	2,150.4	Hours
Wiremesh Installation =	1,757.7	Hours
Final Shotcreting Time =	0.5	Hours
Drilling Drainholes =	6,495.4	Hours
Secondary Mucking =	0.0	Hours
Wick Drain Installation =	0.0	Hours

Overall Advance Rate:

3.4	m / Day
297.4	m^3 / Day

Estimated by: PJP

Checked by: ______________

Resource Type	Resource Name	Unit Rate	Unit	Quantity	Resource Quantity	Total
Labor						
	Miner - Shift Boss	50.68	$/hr	45,527.0	2.00	4,614,616.40
	Miner - Operator - Journeyman	47.84	$/hr	45,527.0	11.00	23,958,126.82
	Miner - Foreman	50.68	$/hr	45,527.0	3.00	6,921,924.60
	Miner - Laborer - Journeyman	47.40	$/hr	45,527.0	5.00	10,789,898.25
	Miner - Laborer - Apprentice	45.00	$/hr	45,527.0	5.00	10,243,574.29
	Tunnel Electrician - Journeyman	47.84	$/hr	45,527.0	4.00	8,712,046.12
					30.00	65,240,186.47
Plant						
	Cable - Fans & Pumps - High Voltage	120.00	$/m	6,500.0	0.20	156,000.00
	Cable - Lights / Controls - Low Voltage	10.00	$/m	6,500.0	0.80	52,000.00
	Compressor	121.77	$/wk	271.0	1.00	33,000.00
	Conveyor - Heading Muck Loading	4,774.09	$/wk	271.0	1.00	1,293,750.00
	Drill - Jack-Leg	77.49	$/wk	271.0	4.00	84,000.00
	Drill Jumbo - Rail Mounted - 2 Boom	968.66	$/wk	271.0	1.00	262,500.00
	Drill Jumbo - Rail Mounted - 6 Boom	2,767.59	$/wk	271.0	1.00	750,000.00
	Excavator - Rail Mounted	304.43	$/wk	271.0	1.00	82,500.00
	Generator - Back-Up - 500KW	290.60	$/wk	271.0	1.00	78,750.00
	Generator - Working - 1000KW	2,169.79	$/wk	271.0	1.00	588,000.00
	Grout Plant-Consol-D&B-Pump, Hoses	182.66	$/wk	271.0	1.00	49,500.00
	Lighting (Including Consumables)	7.50	$/m	6,500.0	1.00	48,750.00
	Locomotive - Diesel - 16T	5,000.00	$/wk	271.0	4.00	5,419,880.58
	LHD Loader - D&B Tunnel	928.53	$/wk	271.0	1.00	251,625.00
	Manlift / Platform - Rail Mounted	405.91	$/wk	271.0	1.00	110,000.00
	Pipe - 50mm (Water Supply)	7.50	$/m	6,500.0	1.00	48,750.00
	Pipe - 100mm (Air Supply)	15.00	$/m	6,500.0	1.00	97,500.00
	Pipe - 150mm (DeWatering)	25.00	$/m	3,250.0	1.00	81,250.00
	Pipe - 250mm (Dewater)	70.00	$/m	3,250.0	1.00	227,500.00
	Pipe - Dewatering Clamps (<=200mm)	7.00	$/m	6,500.0	1.00	45,500.00
	Pumps - Dewatering - Tunnel - 50HP	93.16	$/wk	135.5	15.00	189,337.50
	Rail - 80 lb/yd - Used	101.54	$/m	13,400.0	0.60	816,369.23
	Rail - California Switch Gear	75,000.00	$/Nr	1.0	3.00	225,000.00
	Rail Car - Flat	50,000.00	$/Nr	1.0	3.00	150,000.00
	Rail Car - Man Rider	50,000.00	$/Nr	1.0	1.00	50,000.00
	Rail Car - Muck Cars	1,900.00	$/wk	271.0	18.00	9,267,995.79
	Rail Car - Muck Car Tipping System	75,000.00	$/Nr	1.0	1.00	75,000.00
	Shotcrete Machine - Rail Mounted	445.58	$/wk	271.0	1.00	120,750.00
	Shotcrete Machine - Tire Mounted	721.42	$/wk	271.0	2.00	391,000.00
	Small Tools	200.00	$/wk	271.0	1.00	54,198.81
	Tie Plates, Splice Bars, Bolts	150,000.00	LS	1.0	1.00	150,000.00
	Ties - Wooden - Untreated - 7" x 9" x 40"	23.00	$/m	6,500.0	1.00	149,500.00
	Transformers & Switchgear - High Voltag	202.96	$/wk	271.0	1.00	55,000.00
	Transformers-Switchgear-Low Voltage	101.48	$/wk	271.0	1.00	27,500.00
	Ventilation Duct - Rigid	110.00	$/m	6,500.0	1.00	715,000.00
	Ventilation Fans - 75HP	57.29	$/wk	271.0	7.00	108,675.00
	Welder (Plant)	6.37	$/wk	271.0	1.00	1,725.00
						22,307,806.90

Resource Type	Resource Name	Unit Rate	Unit	Quantity	Resource Quantity	Total
Consumables						
	Bits, Powder and Caps - Blasting	15.00	$/m3	569,293.2	1.00	8,539,397.71
	Bits - (Drainholes & Rockbolts)	5.00	$/m	193,043.1	1.00	965,215.55
	Drill Jumbo Maintenance	100.00	$/hr	9,466.3	1.00	946,630.96
	Electricity - Tunnel Heading Conveyor	0.22	$/kwh	150	496.97	16,400.00
	Electricity - Fans & Lighting	0.22	$/kwh	411	22,763.50	2,058,237.70
	Electricity - Jumbo	0.22	$/kwh	75	9,466.31	156,194.11
	Electricity - Pumps Dewatering	0.22	$/kwh	559	31,868.90	3,921,164.59
	Lubricants	2,500.00	$/wk	271.0	1.00	677,485.07
	Fuels & Lubricants	5,000.00	$/wk	271.0	1.00	1,354,970.14
	Other Consumables	1,500.00	$/wk	271.0	1.00	406,491.04
						$ 19,042,186.89
Materials						
	Grout - Consolidation	50.00	$/m3	2,000.0	1.00	100,000.00
	Other Materials	2,000.00	$/wk	271.0	1.00	541,988.06
	Rock Bolts - No.10 - 3.0m - (Non-Galv)	40.00	$/Nr	61,100	1.00	2,444,000.00
	Shotcrete	180.00	$/m3	6,417.2	1.00	1,155,090.08
	Steel Sets - W10 x 65	152.75	$/m	650	24.53	2,435,334.84
	Synthetic Wick Drains	5.00	$/m	0	1.00	-
	WWF mesh	5.50	$/m2	175,775	1.00	966,760.17
						$ 6,576,412.98
Subcontracts						
	Tunnel Muck - Miscl Surface Handling	20.00	$/m3	910,869.09	1.00	18,217,381.78
						$ 18,217,381.78

Total Estimated Cost: $ **131,383,975.02**

Per Meter: $ 20,212.92

Per m^3: $ 230.78

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[illegible]

Project:	**Newfoundland Fixed Link Study**	**Project Number:**	213789
Estimate Description:	Prefeasibility Level	**Parent Estimate ID:**	V-300
Tunnel Name:	Highway Tunnel - Zones 1,2,4,&5 - Up Drive	**Project Phase:**	Prefeasibility Design
Construction Activity:	Excavation (Drill & Blast) & Initial Support	**Geology Type:**	Poor to Fair Sediments & Volcanics
Estimate Definition ID:	V-318	**Estimate Date:**	June 11 2004

Tunnel Characteristics

Tunnel Length:	**13,748.0**		m
Design Width:	**10.0**		m
Design Wall Height (Ave.)	**9.0**		m
Design Wall to Roof:	**3.0**		
Design Max Height :	12.0		m
Ave Tunnel Overbreak:	**20.0**		cm
Tunnel Face Area:	120.0	(Includes Overbreak)	m^2
Crown Perimeter:	13.4	(Includes Overbreak)	m
Wall & Crown Perimeter:	31.8	(Includes Overbreak)	m
Wall & Crown Area:	436,972	(Includes Overbreak)	m^2
Neat Tunnel Excav. Vol.:	1,649,458	(Includes Overbreak)	m^3
Re-Muck / Pull-Out Bays:			
Bay Length:	**10.0**		m
Spacing Bttn Bays:	**1000.0**		m
Number of Bays:	13		No
Total Length of Bays:	130.0		m
Neat Excavation Vol.:	15,597		m^3
Total Tunnel Volume:	1,665,055		m^3
Muck Bulking Factor:	**1.6**		Ratio
Bulked Tunnel Volume:	2,664,089	(Loose Muck Volume)	m^3

Primary Mucking Production Details

(Activity to remove blast muck from face to conveyor & muck cars)

Muck Volume / Blast:	633.5		m^3
Mucking Volume / Trip:	**5.00**		m^3
Bucket Fill Factor (%):	**90.0**		%
Number of Trips:	141		No
Ave. Dist. to Load:	**35.0**	(Ave Distance One Way)	m
Ave. Tramming Speed:	**8.0**		km/hr
Load, Dump, Manoever:	**1.0**	(Time per Trip)	Min
Face Cleanup / Blast:	**15.0**		Min
Mucking Time:	3.8		Hours
Mucking Rate:	165.5		m^3 / Hour

Tunnel Support Class Details

Class I - No Support:	**0.0**	(%)	0	(m)
Class II - Spot Bolts:	**0.0**	(%)	0	(m)
Class III - Crown Only:	**40.0**	(%)	5,499	(m)
Class IV - Full Pattern:	**50.0**	(%)	6,874	(m)
Class V - Steel Sets:	**10.0**	(%)	1,375	(m)
Total	100.0		13,748	(m)

Initial Shotcrete Support Details

Support Arc Length:	**31.8**	m
Thickness:	**25.0**	mm
Volume / Round:	3.0	m^3

Shift Details

Shift Arrangement:	**3.0**	Shifts / Day
	8.0	Hours / Shift
	7.0	Days / Week

Drill, Charge, Blast, Vent & Mucking Details

Survey Tunnel / Holes / Map:	**30.0**	Min / Cycle
Drilling Blast Holes:		
Hole Length:	**3.9**	m / Hole
Perim. Blast Hole Spacing:	**0.50**	m
Interior Blast Hole Spacing:	**1.25**	m
No. Perimeter Holes:	64	No
No. Interior Area Holes:	76.8	No
No. Blast Initiation Holes:	16	No
Number of Drillholes / Blast:	156	Blastholes / Blast
Blast Hole / Face Area Ratio:	1.30	Holes / m^2
Typical / Check Ratio:	1.05	Holes / m^2
Drill Eqpt Set-Up Time:	**40**	min / Set-up
Drill Penetration Rate:	**0.30**	m / Min
	18	m/hour
# of Drills or Booms:	**6.0**	No
Charging & Blasting:		
Prime & Load Rate / Hole:	**2.50**	min / Blasthole
Prep & Hook-up Time:	**40.0**	min / Set-up
Total No. Blasts / Tunnel:	4205	No
Net Blast Break Length:	**3.3**	m / Blast
Blast & Ventilation Time:	**1.0**	Hours

Pre-Excavation Grouting Details

% Tunnel to be Grouted:	**12.0**	%
Tunnel Length to Grout:	1650	m
Grout Hole Length:	**7.0**	m
No. of Grouting Applications:	236	No
Perim. Grout Holes Spacing:	**1.50**	m
# Perim. Grout Holes:	21	Holes / Grout Cycle
Drilling Penetration Rate:	**50**	m/hour
No. of Drill Booms:	**2**	No
Drilling Time per Cycle:	350	Min
Grout Eqpt. Set-Up Time:	**1.0**	Hours / Grout Cycle
No. of Holes Grouted at Once:	**2**	Hoses
Grouting Injection Rate:	**10**	min / Drillhole
Full Grout Cycle Time:	85.2	Hours

Steel Set Installation Details

Steel Set Spacing:	**1.0**	m
Total No. Sets / Tunnel:	1,375	No
Ave. Installation Time / Set:	**3.0**	Hours

Estimated by ____PJP____
Checked by ____________

Time:	0.8	(Includes Scaling & Equip Set-up)	Hours	**Total Installation Time:**	4,124	Hours

Wiremesh Installation Details

Install Rate:	100	m^2 / Hour
Total Install Time:	4,817.6	Hours
Ave. Install Time:	68.7	Min
Overlap:	5	%
Net Applied Area:	436,972 (Assume Class V only)	m^2
Area with Overlap:	481,762	m^2

Final Shotcrete Support Class Details

Shotcrete Thickness:		
Classes I and II:	0	mm
Class III:	0	mm
Classes IV:	50	mm
Class V:	100	mm
Support Arc Length:		
Class I:	0.0	m
Class II:	0.0	m
Class III:	0.0	m
Class IV:	31.8	m
Class V:	31.8	m

Initial and Final Shotcrete Application Details

Net Volume:	15,294		m^3
Rebound / Waste:	15		%
Final Layer Volume:	17,588		m^3
No. of Applications:	2416	(Required Per Bench)	No.
Ave. Vol. / Application:	7.3		m^3
Surface Prep Time:	10.0		Min
Total Surface Prep Time:	24,163		Min
Application Rate:	24.0		m^3 / Hour
Total Application Time:	43,970		Min
Eqpt. Setup Time:	20.0		Min
Total Setup Time:	48,326		Min
Eqpt. Remove Time:	10.0	(Required Per Application)	Min
Total Remove Time:	24,163		Min
Total Shotcreting Time:	140,623	(For Final Shotcrete Layer)	Min
Equivalent Time / Blast:	33.4		Min / Cycle

Secondary Mucking Details

Req'd during Tunneling:	No	(No if loaded directly into trucks in tunnel)	
Ave. LHD Tram Speed:	0.0		km / hour

Wick Drain Installation Details

Drain Spacing:	0.0	m
Installation Time / Row:	0.0	Hours / Drain

Average Tunneling Productivity Cycle Details

Equiv. Pre-Exc. Grouting:	4.8		Hours
Drilling:	6.3		Hours
Charging:	7.2		Hours
Blast & Venting:	1.0		Hours
Mucking:	3.8		Hours
Scaling:	0.3		Hours
Surveying / Mapping:	0.5		Hours
Initial Shotcreting:	0.8		Hours
Install Services:	0.5	(Equiv. Time Per Cycle)	Hours
Non-Productive Time:	0.5	(Travel in/out, Break)	Hours
Include Rockbolting:	Yes	(Yes / No, as part of Cycle Time)	
If yes, % of Support Rq'd:	30	(% Req'd During Cycle for Poorer Ground)	
Rockbolting:	0.3		Hours
Total Cycle Time:	26.1		Hours

Rockbolt Support Class Details

	(Bolts Per Row)	(Bolts Per m)	(Bolts Per Support Class)
Class I:	0	0.0	0
Class II:	0.0	0.0	0
Class III:	6	4.0	21,997
Class IV:	15	10.0	68,740
Class V:	0	0.0	0
Total:			90,737

Face Scaling

Scaling Time:	20.0	min / Blast

Rockbolt Installation Details

Rockbolt Length:	3.0	m
Row Spacing:	1.5	m
No. Rockbolts Required:	90,737	No.
Ave. Bolts / Round:	21.8	Bolts / Blast
Drilled Length / Round:	65	m
Total Drilling Length:	272,210	m
Drill Penetration Rate:	1.5	m / Min
# of Drills / Booms Used:	3	No.
Ave. Drilling Time / Round:	14.5	Min
Bolt Install Rate	2.0	Min / Bolt
Ave. Bolt Install Time:	43.6	Min
Drill Set-Up Time:	10.0	Min
Total Bolt Drill/Install Time:	68.1	Min

Drainhole Details

Drainhole Spacing:	3.0	m
Drainhole Length:	1.1	m
Total Area:	218,486.1	m^2
Total Drainholes:	24,276.2	# / Per Tunnel
Total Length:	26,703.9	m

Note: Activity carried out concurrent with other activities

Duration of Tunneling:

Pre-Exc. Grouting Time =	20,072.8	Hours
Drilling Time =	26,567.2	Hours
Charge, Blast, Vent Time =	34,428.6	Hours
Primary Mucking Time =	16,098.5	Hours
Scaling Time =	4,205.8	Hours
Survey / Map Time =	2,102.7	Hours
Install Steel Sets Time =	4,124.4	Hours
Initial Shotcreting Time =	3,332.0	Hours
Install Services Time =	2,102.7	Hours
Rockbolting (of % Critical) =	1,431.5	Hours
Non-Productive Time =	2,102.7	Hours
Total Time =	116,569.1	Hours
	160.1	Months
(Critical Path Tunneling Activities Only)	693.9	Weeks
	4,857.0	Days

Other Concurrent Tunneling Activities

Rockbolting (of % Not Critical) =	3,340.3	Hours
Wiremesh Installation =	4,817.6	Hours
Final Shotcreting Time =	0.6	Hours
Drilling Drainholes =	17,802.6	Hours
Secondary Mucking =	0.0	Hours
Wick Drain Installation =	0.0	Hours

Overall Advance Rate:

2.8	m / Day
339.6	m^3 / Day

Estimated by PJP
Checked by

Resource Type	Resource Name	Unit Rate	Unit	Quantity	Resource Quantity	Total
Labor						
	Miner - Shift Boss	50.68	$/hr	116,569.1	2.00	11,815,445.90
	Miner - Operator - Journeyman	47.84	$/hr	116,569.1	11.00	61,343,333.16
	Miner - Foreman	50.68	$/hr	116,569.1	3.00	17,723,168.85
	Miner - Laborer - Journeyman	47.40	$/hr	116,569.1	5.00	27,626,881.19
	Miner - Laborer - Apprentice	45.00	$/hr	116,569.1	5.00	26,228,051.76
	Tunnel Electrician - Journeyman	47.84	$/hr	116,569.1	4.00	22,306,666.60
					30.00	167,043,547.46
Plant						
	Cable - Fans & Pumps - High Voltage	120.00	$/m	13,748.0	0.20	329,952.00
	Cable - Lights / Controls - Low Voltage	10.00	$/m	13,748.0	0.80	109,984.00
	Compressor	121.77	$/wk	693.9	1.00	84,494.50
	Conveyor - Heading Muck Loading	4,774.09	$/wk	693.9	1.00	3,312,568.54
	Drill - Jack-Leg	77.49	$/wk	693.9	4.00	215,076.91
	Drill Jumbo - Rail Mounted - 2 Boom	968.66	$/wk	693.9	1.00	672,115.36
	Drill Jumbo - Rail Mounted - 3 Boom	[illegible]7.59	$/wk	693.9	1.00	1,920,329.59
	Excavator - Rail Mounted	304.43	$/wk	693.9	1.00	211,236.26
	Generator - Back-Up - 500KW	290.60	$/wk	693.9	1.00	201,634.61
	Generator - Working - 1000KW	2,169.79	$/wk	693.9	1.00	1,505,538.40
	Grout Plant-Consol-D&B-Pump, Hoses	182.66	$/wk	693.9	1.00	126,741.75
	Lighting (Including Consumables)	7.50	$/m	13,748.0	1.00	103,110.00
	Locomotive - Diesel - 16T	5,000.00	$/wk	693.9	4.00	13,877,276.07
	LHD Loader - D&B Tunnel	928.53	$/wk	693.9	1.00	644,270.58
	Manlift / Platform - Rail Mounted	405.91	$/wk	693.9	1.00	281,648.34
	Pipe - 50mm (Water Supply)	7.50	$/m	13,748.0	1.00	103,110.00
	Pipe - 100mm (Air Supply)	15.00	$/m	13,748.0	1.00	206,220.00
	Rail - 80 lb/yd - Used	101.54	$/m	27,896.0	0.60	1,699,510.15
	Rail - California Switch Gear	75,000.00	$/Nr	1.0	3.00	225,000.00
	Rail Car - Flat	50,000.00	$/Nr	1.0	3.00	150,000.00
	Rail Car - Man Rider	50,000.00	$/Nr	1.0	1.00	50,000.00
	Rail Car - Muck Cars	1,900.00	$/wk	693.9	18.00	23,730,142.07
	Rail Car - Muck Car Tipping System	75,000.00	$/Nr	1.0	1.00	75,000.00
	Shotcrete Machine - Rail Mounted	445.58	$/wk	693.9	1.00	309,173.06
	Shotcrete Machine - Tire Mounted	721.42	$/wk	693.9	2.00	1,001,131.83
	Small Tools	200.00	$/wk	693.9	1.00	138,772.76
	Tie Plates, Splice Bars, Bolts	150,000.00	LS	1.0	1.00	150,000.00
	Ties - Wooden - Untreated - 7" x 9" x 40"	23.00	$/m	13,748.0	1.00	316,204.00
	Transformers & Switchgear - High Voltag	202.96	$/wk	693.9	1.00	140,824.17
	Transformers-Switchgear-Low Voltage	101.48	$/wk	693.9	1.00	70,412.09
	Ventilation Duct - Rigid	110.00	$/m	13,748.0	1.00	1,512,280.00
	Ventilation Fans - 75HP	57.29	$/wk	693.9	7.00	278,255.76
	Welder (Plant)	6.37	$/wk	693.9	1.00	4,416.76
						53,756,429.56
Consumables						
	Bits, Powder and Caps - Blasting	15.00	$/m3	1,665,055.4	1.00	24,975,830.85
	Bits - (Drainholes & Rockbolts)	5.00	$/m	298,914.3	1.00	1,494,571.27
	Drill Jumbo Maintenance	100.00	$/hr	25,266.3	1.00	2,526,627.68
	Electricity - Tunnel Heading Conveyor	0.22	$/kwh	150	1,051.36	34,695.00
	Electricity - Fans & Lighting	0.22	$/kwh	433	58,284.56	5,548,807.71
	Electricity - Jumbo	0.22	$/kwh	75	25,266.28	416,893.57
	Lubricants	2,500.00	$/wk	693.9	1.00	1,734,659.51
	Fuels & Lubricants	5,000.00	$/wk	693.9	1.00	3,469,319.02
	Other Consumables	1,500.00	$/wk	693.9	1.00	1,040,795.70

Estimated by PJP

Checked by

Resource Type	Resource Name	Unit Rate	Unit	Quantity	Resource Quantity	Total
						$ 41,242,200.30

Estimated by: PJP
Checked by: ____________

Resource Type	Resource Name	Unit Rate	Unit	Quantity	Resource Quantity	Total
Materials						
	Grout - Consolidation	50.00	$/m3	2,000.0	1.00	100,000.00
	Other Materials	2,000.00	$/wk	693.9	1.00	1,387,727.61
	Rock Bolts - No.10 - 3.0m - (Non-Galv)	40.00	$/Nr	90,737	1.00	3,629,472.00
	Shotcrete	180.00	$/m3	17,588.1	1.00	3,165,863.32
	Steel Sets - W10 x 65	152.75	$/m	1,375	31.78	6,674,749.78
	Synthetic Wick Drains	5.00	$/m	0	1.00	-
	WWF mesh	5.50	$/m2	481,762	1.00	2,649,689.95
						$ 14,857,812.70
Subcontracts						
	Tunnel Muck - Miscl Surface Handling	20.00	$/m3	2,664,088.62	1.00	53,281,772.48
						$ 53,281,772.48

Total Estimated Cost: $ **330,181,762.51**

Per Meter: $ 24,016.71

Per m^3: $ 198.30

Estimated by PJP
Checked by ____________

Newfoundland Fixed Link Pre-feasibility Study
Drill and Blast Highway Tunnel - Zones 1, 3, and 5
Tunnel Final Liner Cost Estimate

Tunnel length= 6500 m
Liner cross section area= 15 m2

Shift pattern

Shifts	Hours	Days
3	8	5

Advance rate= 10 m/day

Rebar ratio= 0.12 t/m3 of concrete

Concrete supply=$ 135 /m3

Rebar supply=$ 900 /t

Initial form set-up time= 4 weeks

Durations

Number of days= 670 days
Number of hours= 16080 hours
Number of weeks= 134 weeks

Labour

Crew size 30
Average labour rate $ 47 /hour

Total labour cost=$ 22,672,800

Equipment

Form $ 1000000
Weekly cost of other equipment $ 15000 (see TED 2370)

Total equipment cost=$ 3,010,000

Materials

Concrete= 97500 m3
Rebar= 11700

Concrete cost=$ 13,162,500
Rebar cost=$ 10,530,000

Total material cost=$ 23,692,500

Cost Summary

Labour	22,672,800
Equipment	3,010,000
Materials	23,692,500
Total	**49,375,300**

Newfoundland Fixed Link Pre-feasibility Study
Drill and Blast Highway Tunnel - Zones 1, 3, and 5
Tunnel Final Liner Cost Estimate

Tunnel length= 13748 m
Liner cross section area= 17.2 m2

Shift pattern

Shifts	Hours	Days
3	8	5

Advance rate= 10 m/day

Rebar ratio= 0.12 t/m3 of concrete

Concrete supply=$ 135 /m3

Rebar supply=$ 900 /t

Initial form set-up time= 4 weeks

Durations

Number of days= 1395 days
Number of hours= 33475 hours
Number of weeks= 279 weeks

Labour

Crew size 30
Average labour rate $ 40 /hour

Total labour cost=$ 40,170,240

Equipment

Form $ 1000000
Weekly cost of other equipment $ 15000 (see TED 2370)

Total equipment cost=$ 5,184,400

Materials

Concrete= 236465.6 m3
Rebar= 28375.872

Concrete cost=$ 31,922,856
Rebar cost=$ 25,538,285

Total material cost=$ 57,461,141

Cost Summary

Labour	40,170,240
Equipment	5,184,400
Materials	57,461,141
Total	**102,815,781**

Newfoundland Fixed Link Pre-feasibility Study
Drill and Blast Highway Tunnel - Zones 1, 3, and 5
Tunnel Final Liner Cost Estimate

Tunnel length= 6500 m
Liner cross section area= 15 m2

Shift pattern

Shifts	Hours	Days
3	8	5

Advance rate= 10 m/day

Rebar ratio= 0.12 t/m3 of concrete

Concrete supply=$ 135 /m3

Rebar supply=$ 900 /t

Initial form set-up time= 4 weeks

Durations

Number of days= 670 days
Number of hours= 16080 hours
Number of weeks= 134 weeks

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Cost Summary

Labour	22,672,800
Equipment	3,010,000
Materials	23,692,500
Total	**49,375,300**

Newfoundland Fixed Link Pre-feasibility Study
Drill and Blast Highway Tunnel - Zones 1, 3, and 5
Tunnel Final Liner Cost Estimate

Tunnel length= 13748 m
Liner cross section area= 17.2 m2

Shift pattern

Shifts	Hours	Days
3	8	5

Advance rate= 10 m/day

Rebar ratio= 0.12 t/m3 of concrete

Concrete supply=$ 135 /m3

Rebar supply=$ 900 /t

Initial form set-up time= 4 weeks

Durations

Number of days= 1395 days
Number of hours= 33475 hours
Number of weeks= 279 weeks

Labour

Crew size 30
Average labour rate $ 40 /hour

Total labour cost=$ 40,170,240

Equipment

Form $ 1000000
Weekly cost of other equipment $ 15000 (see TED 2370)

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Concrete= 236465.6 m3
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Total material cost=$ 57,461,141

Cost Summary

Labour	40,170,240
Equipment	5,184,400
Materials	57,461,141
Total	102,815,781

Main Electrical Components for Novaroute
Drill & Blast Highway Tunnel Option

Length of each tunnel= 20248 m Number of tunnels= 1
Tunnel width= 9.5 m

Item	Component	Unit	Qty	Unit Cost	Total Cost
	Lighting				
	Threshold + transition (1st 700m)	m2	7280	315	2293200
	Interior (balance)	m2	185706	120.00	22284720
				Lighting subtotal	0
	Substations, generators, UPS				
	Substations	Ea	2	1337000	2674000
	Emergency generator	Ea	1	955000	955000
	UPS (Battery system)	Ea	1	573000	573000
				Substations, generators, UPS subtotal	4202000
	CCTV system				
	Cameras (every 60m)	Each	337	3100	1044700
	Control station	Each	1	30000	30000
				CCTV system subtotal	1074700
	Provide power for gas detection, ventilation etc.				
	Power provision	m	20248	45	911160
				Power subtotal	911160
	Lane control system				
	Fibre optic display (every 200m)	Each	101	12500	0
				Lane control system subtotal	0

Lighting costed elsewhere

Total Electrical 6187860

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: North Approach
Option: D&B Highway Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient 2.87 %

+ sloping same way as track/road
- sloping against track/road

Track/Road Gradient 6 %

Ground elevation at portal 100 m

Bottom of slab elevation at portal 81.6 m

Total length= 587.8594 m

Total Cost=$ 10.6 M

Main Electrical Components for Novaroute
Drill & Blast Highway Tunnel Option

Length of each tunnel= 20248 m
Tunnel width= 9.5 m
Number of tunnels= 1

Item	Component	Unit	Qty	Unit Cost	Total Cost
	Lighting				
	Threshold + transition (1st 700m)	m2	7280	315	2293200
	Interior (balance)	m2	185706	120.00	22284720
				Lighting subtotal	0
	Substations, generators, UPS				
	Substations	Ea	2	1337000	2674000
	Emergency generator	Ea	1	955000	955000
	UPS (Battery system)	Ea	1	573000	573000
				Substations, generators, UPS subtotal	4202000
	CCTV system				
	Cameras (every 60m)	Each	337	3100	1044700
	Control station	Each	1	30000	30000
				CCTV system subtotal	1074700
	Provide power for gas detection, ventilation etc.				
	Power provision	m	20248	45	911160
				Power subtotal	911160
	Lane control system				
	Fibre optic display (every 200m)	Each	101	12500	0
				Lane control system subtotal	0

Lighting costed elsewhere

Total Electrical 6187860

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: North Approach
Option: D&B Highway Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient	2.87	%	+ sloping same way as track/road - sloping against track/road
Track/Road Gradient	6	%	
Ground elevation at portal	100	m	
Bottom of slab elevation at portal	81.6	m	

Total length= 587.8594 m

Total Cost=$ 10.6 M

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
D&B Highway Tunnel

UNIT RATES

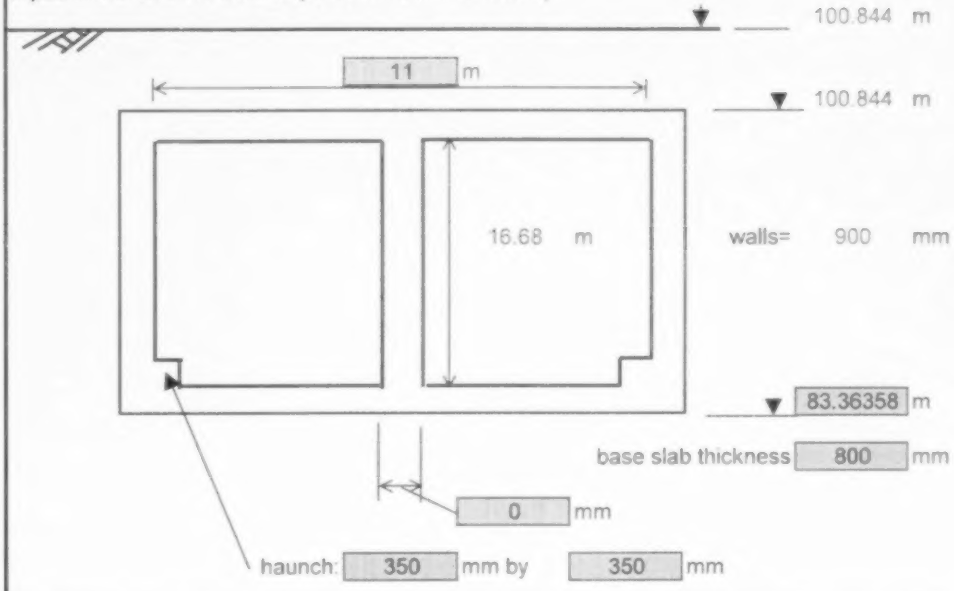
Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
D&B Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 58.78594 m **Section 1**

Input cross-section details (cut and cover solution)


100.844 m
11 m
100.844 m
16.68 m
walls= 900 mm
83.36358 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation= 13153.0 m3
concrete= 2381.36 m3
rebar= 285.8 tonnes (assume 0.12t/m3 of concrete)
formwork/falsework= 1961.099 m2
SP&L<=4.6m deep 0.0 m2
4.6<SP&L<=6.7m deep 0.0 m2
6.7<SP&L<=10.6m deep 0.0 m2
10.6<SP&L<=13.7m deep 0.0 m2
13.7<SP&L<=16.8m deep 0.0 m2
16.8<SP&L<=20.0m deep 2055.2 m2
20<SP&L<=25m deep 0.0 m2
backfill= 0 m3
surface reinstatement= 752.4601 m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
D&B Highway Tunnel

UNIT RATES

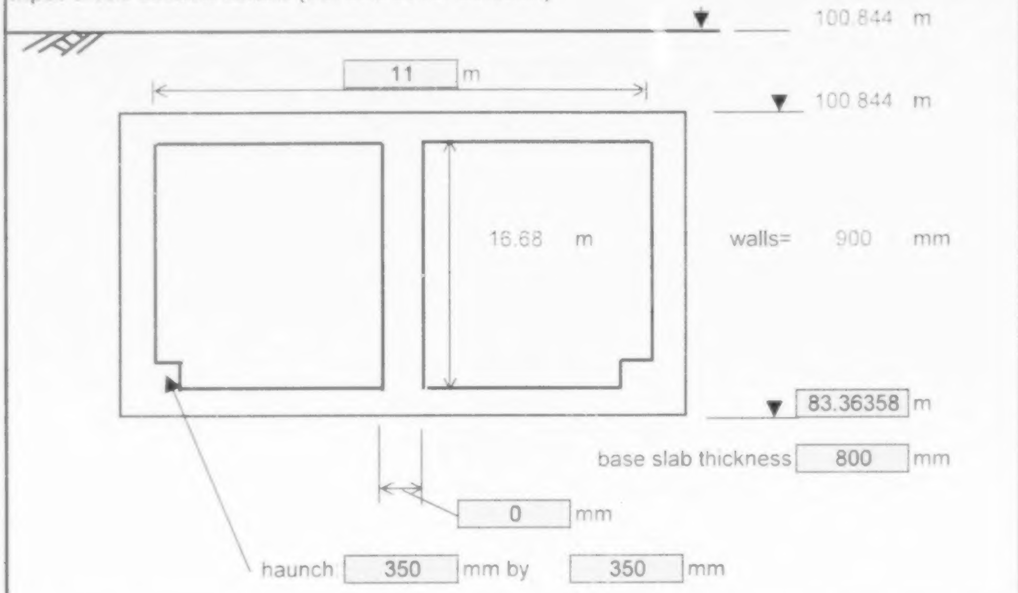
Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
D&B Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 58.78594 m **Section 1**

Input cross-section details (cut and cover solution)


100.844 m
11 m
100.844 m
16.68 m
walls= 900 mm
83.36358 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	13153.0	m3	
concrete=	2381.36	m3	
rebar=	285.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1961.099	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	2055.2	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	752.4601	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	13153.0	60	789180.1
concrete	m3	2381.36	190.0	452458.4
rebar	tonnes	285.8	1600	457221.1
formwork/falsework	m2	1961.099	140	274553.9
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	2055.2	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	752.4601	30	22573.8
			Total	1995987

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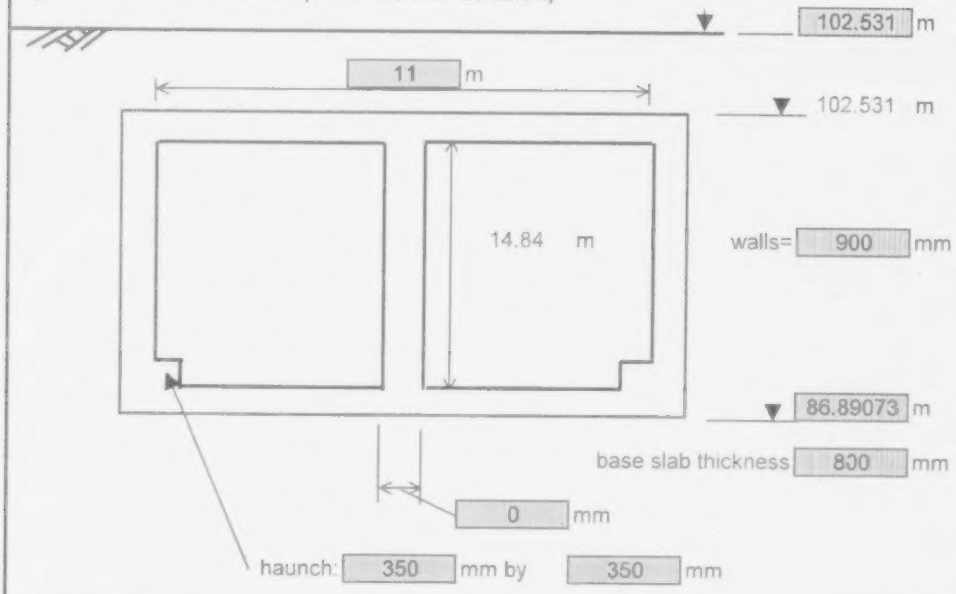
Section Cut and Cover
Length of section: 58.78594 m
Section 2

Input cross-section details (cut and cover solution)



walls= 900 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	11768.5	m3	
concrete=	2186.661	m3	
rebar=	262.4	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1744.767	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	1838.8	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	752.4601	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
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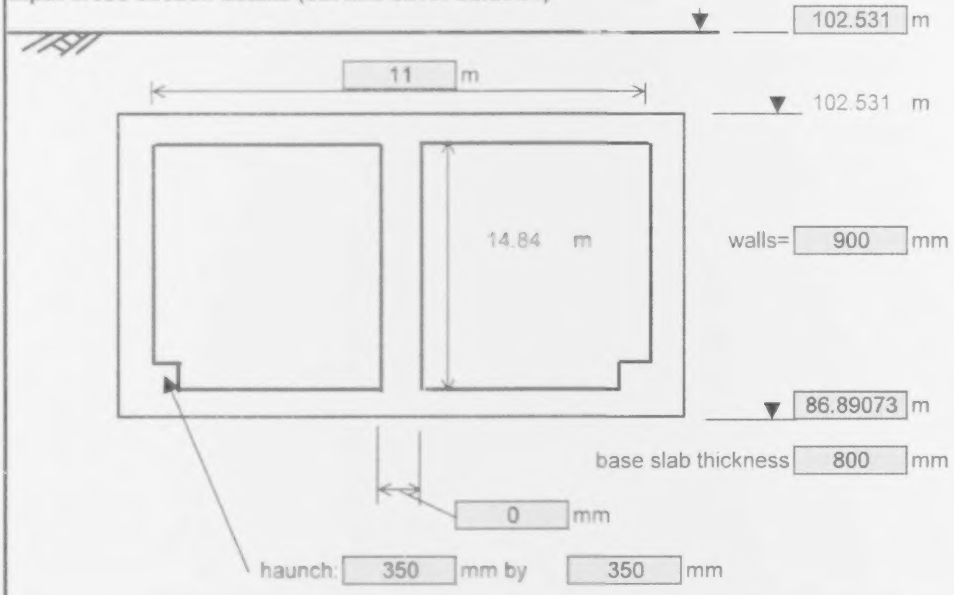
Section Cut and Cover
Length of section: 58.78594 m **Section** 2

Input cross-section details (cut and cover solution)



walls= 900 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	11768.5	m3	
concrete=	2186.661	m3	
rebar=	262.4	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1744.767	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	1838.8	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	752.4601	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	11768.5	60	706108.5
concrete	m3	2186.661	190.0	415465.5
rebar	tonnes	262.4	1600	419838.9
formwork/falsework	m2	1744.767	140	244267.3
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	1838.8	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	752.4601	30	22573.8
			Total	1808254

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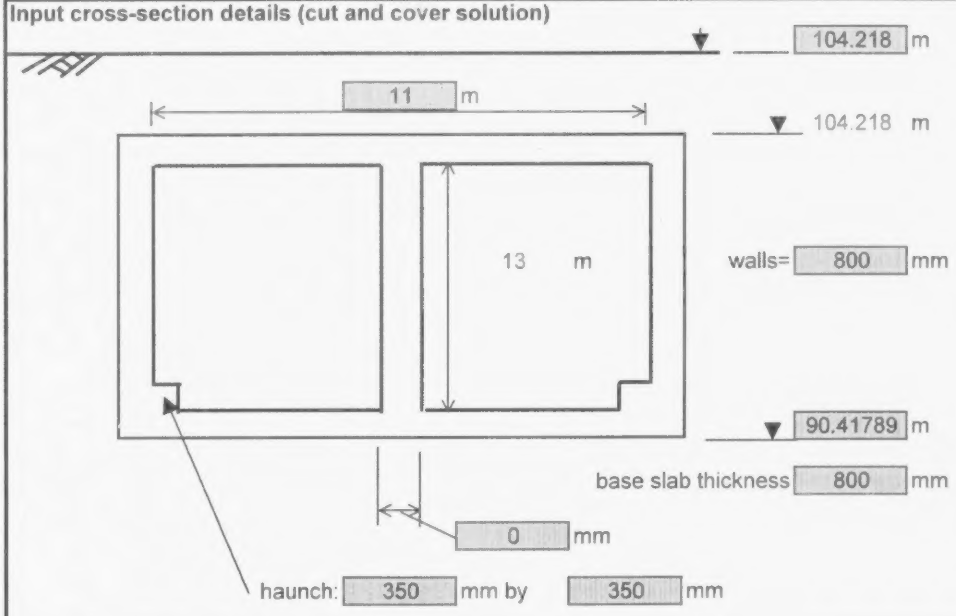
Section Cut and Cover
Length of section: 58.78594 m **Section** 3

Input cross-section details (cut and cover solution)


104.218 m
11 m
104.218 m
13 m
walls= 800 mm
90.41789 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	10221.7	m3	
concrete=	1829.712	m3	
rebar=	219.6	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1528.435	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	1622.5	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	740.7029	m2	

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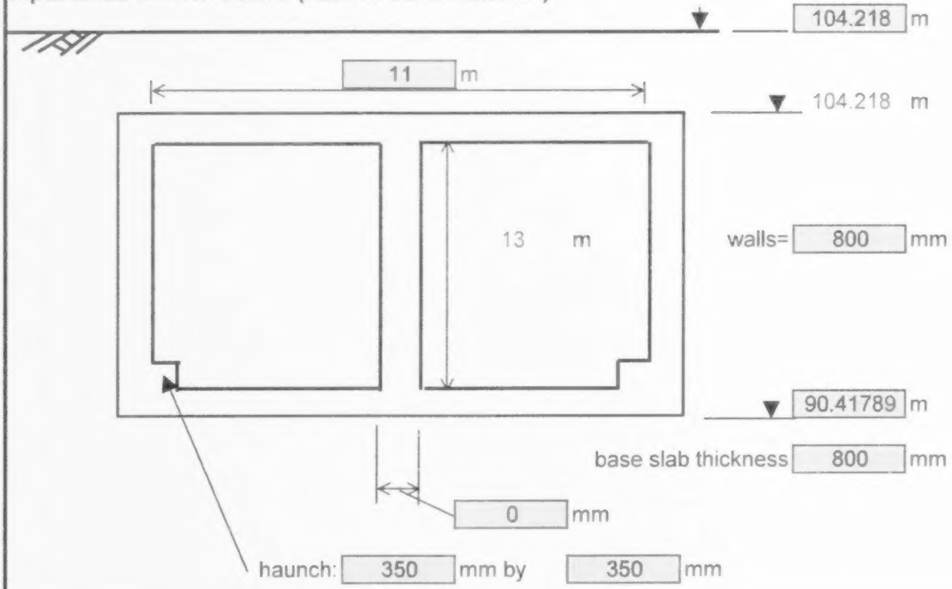
Section Cut and Cover
Length of section: 58.78594 m
Section 3

Input cross-section details (cut and cover solution)


104.218 m
11 m
104.218 m
13 m
walls= 800 mm
90.41789 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	10221.7	m3	
concrete=	1829.712	m3	
rebar=	219.6	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1528.435	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	1622.5	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	740.7029	m2	

Newfoundland Fixed Link Pre-feasibility Study
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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	10221.7	60	613302
concrete	m3	1829.712	190.0	347645.4
rebar	tonnes	219.6	1600	351304.8
formwork/falsework	m2	1528.435	140	213980.8
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	1622.5	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	740.7029	30	22221.09
			Total	1548454

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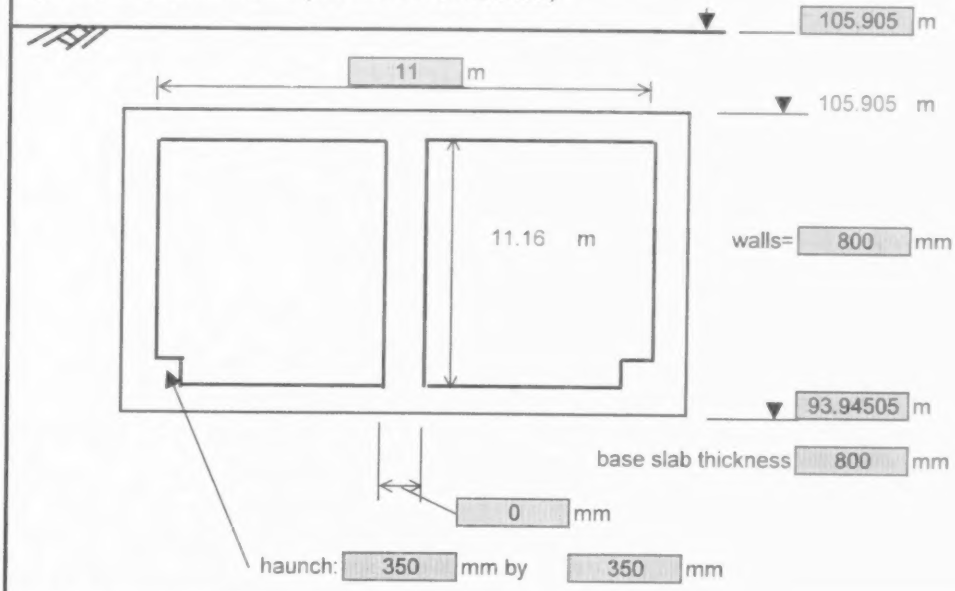
Section Cut and Cover
Length of section: 58.78594 m
Section 4

Input cross-section details (cut and cover solution)



walls= 800 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	8858.8	m3	
concrete=	1656.647	m3	
rebar=	198.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1312.102	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1406.2	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	740.7029	m2	

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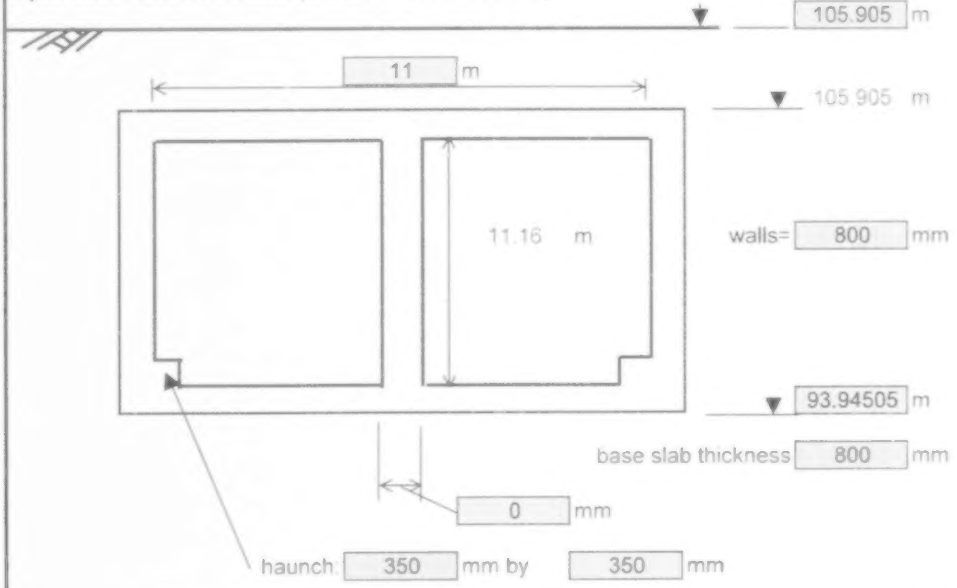
Section Cut and Cover
Length of section: 58.78594 m
Section **4**

Input cross-section details (cut and cover solution)


105.905 m
11 m
105.905 m
11.16 m
walls= 800 mm
93.94505 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	8858.8	m3	
concrete=	1656.647	m3	
rebar=	198.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1312.102	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1406.2	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	740.7029	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	8858.8	60	531528.4
concrete	m3	1656.647	190.0	314762.9
rebar	tonnes	198.8	1600	318076.2
formwork/falsework	m2	1312.102	140	183694.3
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	1406.2	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	740.7029	30	22221.09
			Total	1370283

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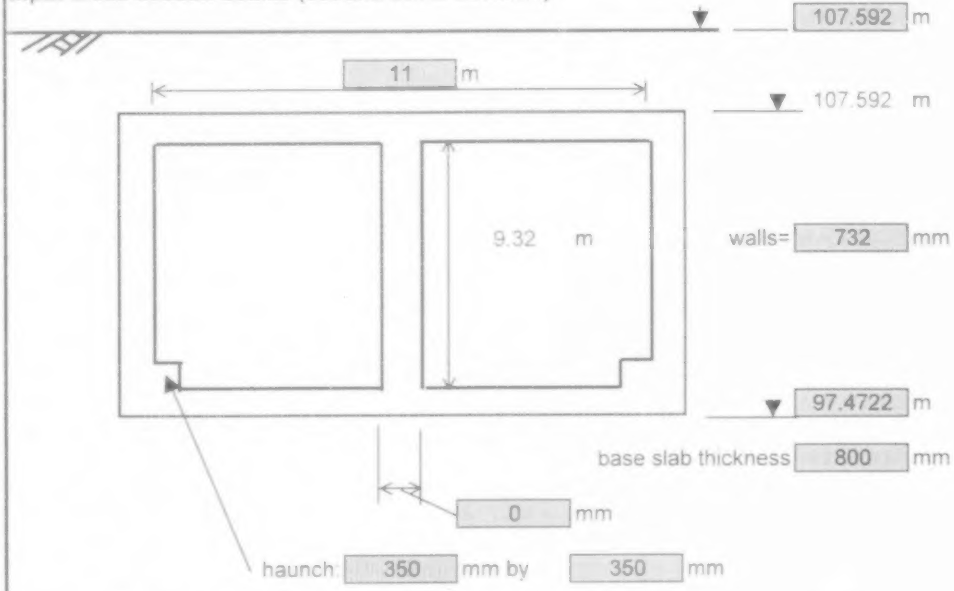
Section Cut and Cover

Length of section: 58.78594 m **Section** 5

Input cross-section details (cut and cover solution)



107.592 m
11 m
107.592 m
9.32 m
walls= 732 mm
97.4722 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	7415.0	m3	
concrete=	1402.673	m3	
rebar=	168.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1095.77	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1189.8	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	732.708	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	7415.0	60	444900.3
concrete	m3	1402.673	190.0	266507.8
rebar	tonnes	168.3	1600	269313.1
formwork/falsework	m2	1095.77	140	153407.8
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1189.8	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	732.708	30	21981.24
			Total	1156110

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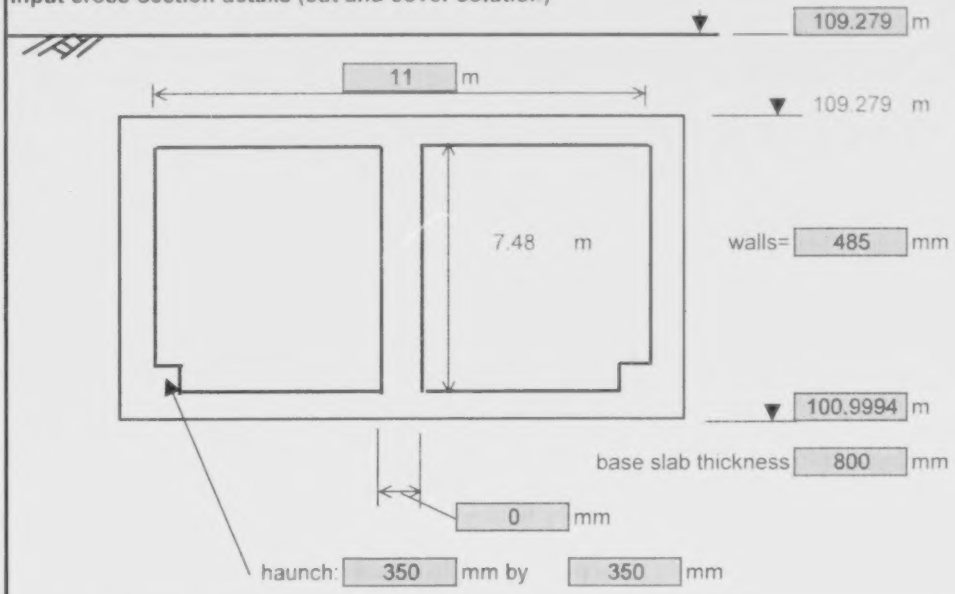
Section Cut and Cover
Length of section: 58.78594 m **Section 6**

Input cross-section details (cut and cover solution)



109.279 m
11 m
109.279 m
7.48 m
walls= 485 mm
100.9994 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	5826.4	m3	
concrete=	1003.864	m3	
rebar=	120.5	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	879.4377	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	973.5	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	703.6677	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	5826.4	60	349582.1
concrete	m3	1003.864	190.0	190734.2
rebar	tonnes	120.5	1600	192741.9
formwork/falsework	m2	879.4377	140	123121.3
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	973.5	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	703.6677	30	21110.03
			Total	877289.5

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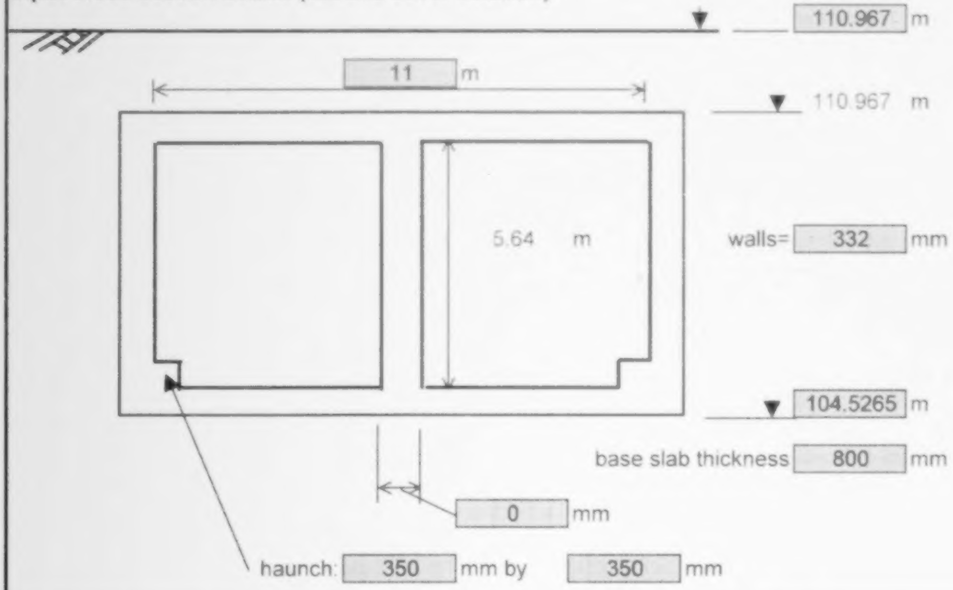
Section Cut and Cover
Length of section: 58.78594 m **Section** 7

Input cross-section details (cut and cover solution)


110.967 m
11 m
110.967 m
5.64 m
walls= 332 mm
104.5265 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	4415.8	m3	
concrete=	783.0969	m3	
rebar=	94.0	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	663.1054	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	757.2	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	685.6792	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	4415.8	60	264946.5
concrete	m3	783.0969	190.0	148788.4
rebar	tonnes	94.0	1600	150354.6
formwork/falsework	m2	663.1054	140	92834.76
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	757.2	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	685.6792	30	20570.38
			Total	677494.6

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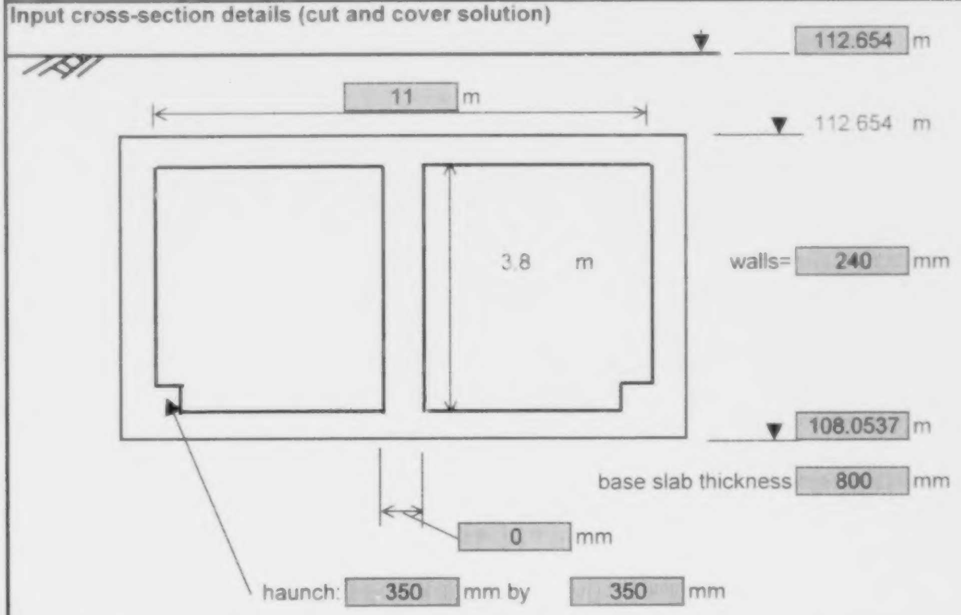
Section Cut and Cover
Length of section: 58.78594 m **Section** **8**

Input cross-section details (cut and cover solution)



112.654 m
11 m
112.654 m
3.8 m
walls= 240 mm
108.0537 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	3104.4	m3	
concrete=	661.5182	m3	
rebar=	79.4	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	446.7732	m2	
SP&L<=4.6m deep	540.8	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	674.8626	m2	

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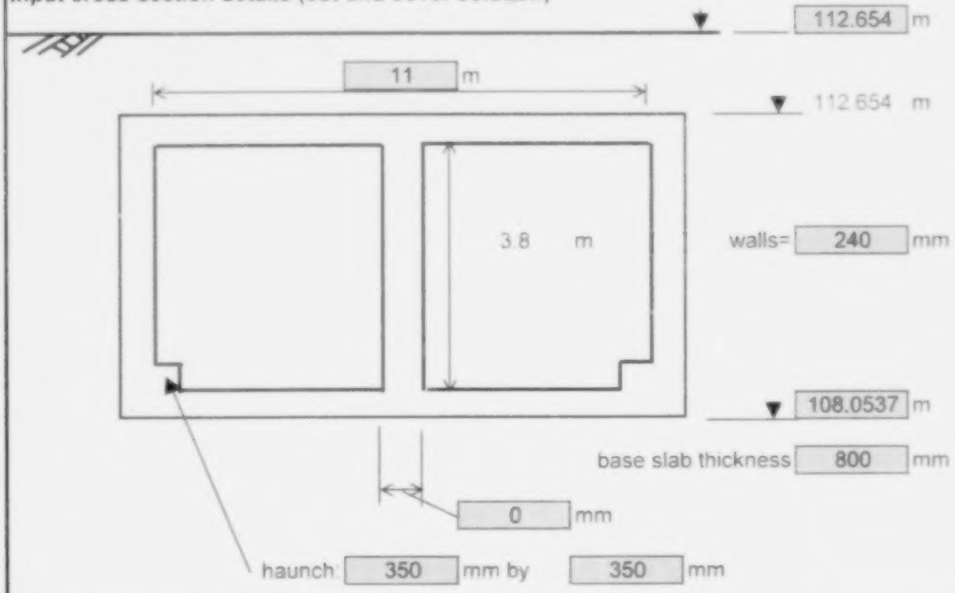
Section Cut and Cover
Length of section: 58.78594 m **Section** 8

Input cross-section details (cut and cover solution)



112.654 m
11 m
112.654 m
3.8 m
walls= 240 mm
108.0537 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	3104.4	m3	
concrete=	661.5182	m3	
rebar=	79.4	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	446.7732	m2	
SP&L<=4.6m deep	540.8	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	674.8626	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
D&B Highway Tunnel **Page 2 of 2**

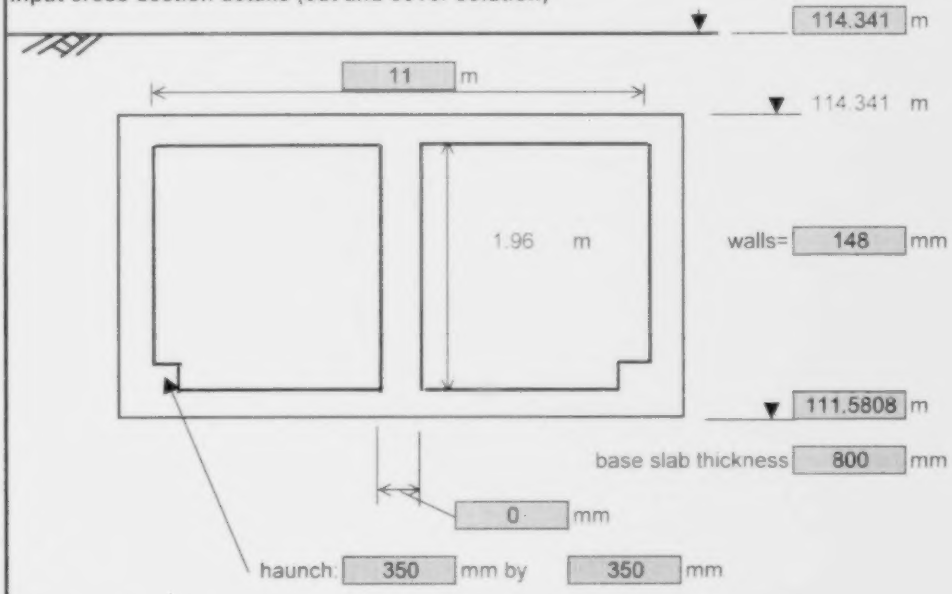
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	3104.4	60	186262.1
concrete	m3	661.5182	190.0	125688.5
rebar	tonnes	79.4	1600	127011.5
formwork/falsework	m2	446.7732	140	62548.24
SP&L<=4.6m deep	m2	540.8	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	674.8626	30	20245.88
			Total	521756.2

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
North Approach	**Calculations by:** ANW
D&B Highway Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 58.78594 m **Section 9**

Input cross-section details (cut and cover solution)


114.341 m
11 m
114.341 m
1.96 m
walls= 148 mm
111.5808 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

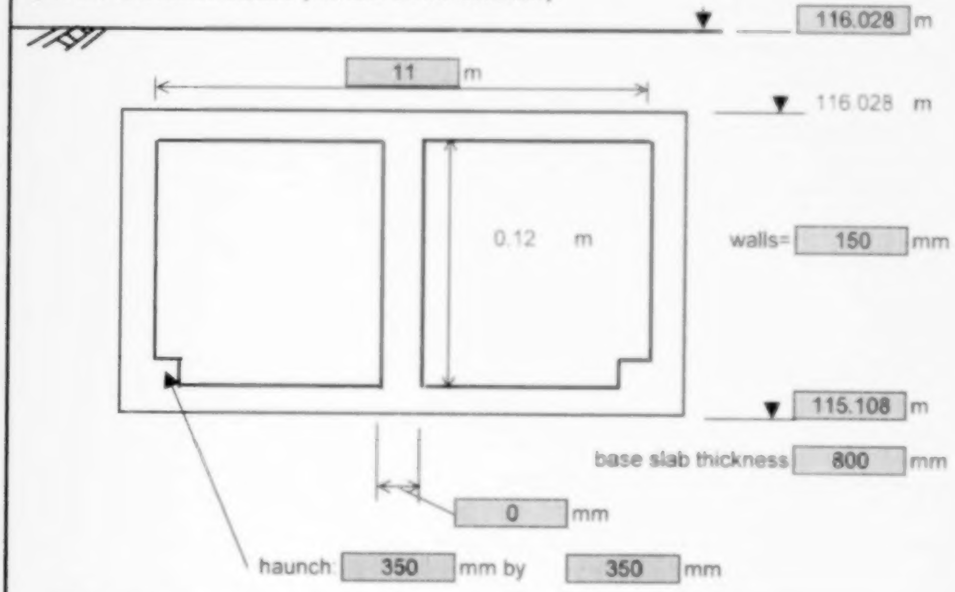
Calculated Quantities

excavation=	1832.8	m3
concrete=	579.7446	m3
rebar=	69.6	tonnes (assume 0.12t/m3 of concrete)
formwork/falsework=	230.4409	m2
SP&L<=4.6m deep	324.5	m2
4.6<SP&L<=6.7m deep	0.0	m2
6.7<SP&L<=10.6m deep	0.0	m2
10.6<SP&L<=13.7m deep	0.0	m2
13.7<SP&L<=16.8m deep	0.0	m2
16.8<SP&L<=20.0m deep	0.0	m2
20<SP&L<=25m deep	0.0	m2
backfill=	0	m3
surface reinstatement=	664.046	m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
D&B Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 58.78594 m **Section** 10

Input cross-section details (cut and cover solution)


116.028 m
11 m
116.028 m
0.12 m
walls= 150 mm
115.108 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	611.1	m3	
concrete=	547.9438	m3	
rebar=	65.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	14.10863	m2	
SP&L<=4.6m deep	108.2	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	664.2812	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
D&B Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	1832.8	60	109966
concrete	m3	579.7446	190.0	110151.5
rebar	tonnes	69.6	1600	111311
formwork/falsework	m2	230.4409	140	32261.73
SP&L<=4.6m deep	m2	324.5	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	664.046	30	19921.38
			Total	383611.6

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
D&B Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	611.1	60	36668.32
concrete	m3	547.9438	190.0	104109.3
rebar	tonnes	65.8	1600	105205.2
formwork/falsework	m2	14.10863	140	1975.208
SP&L<=4.6m deep	m2	108.2	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	664.2812	30	19928.43
			Total	267886.5

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
D&B Highway Tunnel

Summary of Costs

Markup for adjacent 0 %

Section	**Cost**
1	1995987
2	1808254
3	1548454
4	1370283
5	1156110
6	877289.5
7	677494.6
8	521756.2
9	383611.6
10	267886.5
Sub-total	10607127

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: South Approach
Option: D&B Highway Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient	0.5	%	+ sloping same way as track/road - sloping against track/road
Track/Road Gradient	6	%	
Ground elevation at portal	100	m	
Bottom of slab elevation at portal	81.6	m	
Total length=	334.5455	m	
Total Cost=$	6.0	M	

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
D&B Highway Tunnel	

UNIT RATES

Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: South Approach
Option: D&B Highway Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient	0.5	%	+ sloping same way as track/road - sloping against track/road
Track/Road Gradient	6	%	
Ground elevation at portal	100	m	
Bottom of slab elevation at portal	81.6	m	
Total length=	334.5455	m	
Total Cost=$	6.0	M	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
D&B Highway Tunnel

UNIT RATES

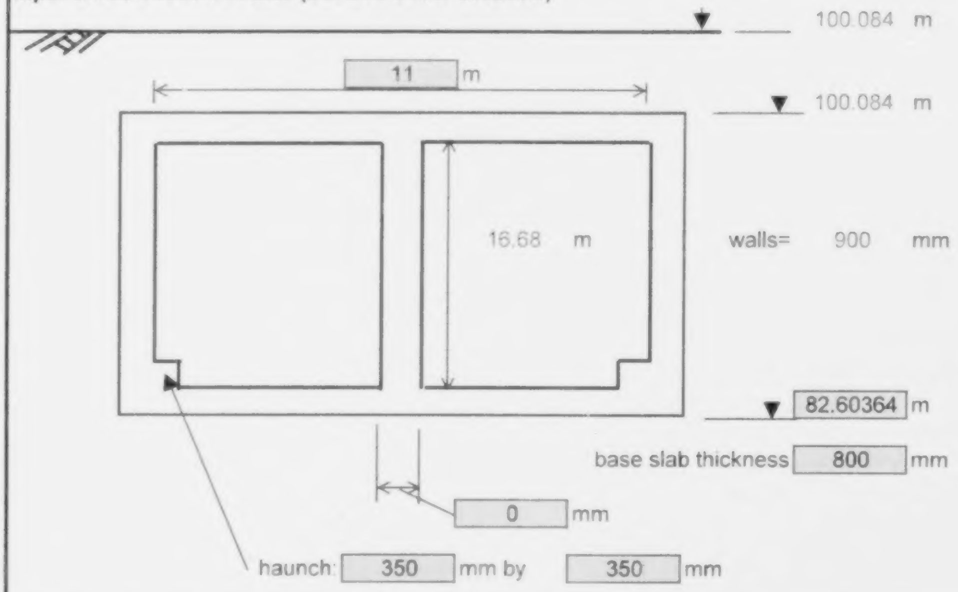
Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
D&B Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 33.45455 m **Section** 1

Input cross-section details (cut and cover solution)



walls= 900 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	7485.3	m3
concrete=	1355.21	m3
rebar=	162.6	tonnes (assume 0.12t/m3 of concrete)
formwork/falsework=	1116.044	m2
SP&L<=4.6m deep	0.0	m2
4.6<SP&L<=6.7m deep	0.0	m2
6.7<SP&L<=10.6m deep	0.0	m2
10.6<SP&L<=13.7m deep	0.0	m2
13.7<SP&L<=16.8m deep	0.0	m2
16.8<SP&L<=20.0m deep	1169.6	m2
20<SP&L<=25m deep	0.0	m2
backfill=	0	m3
surface reinstatement=	428.2182	m2

Newfoundland Fixed Link Pre-feasibility Study
South Approach
D&B Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
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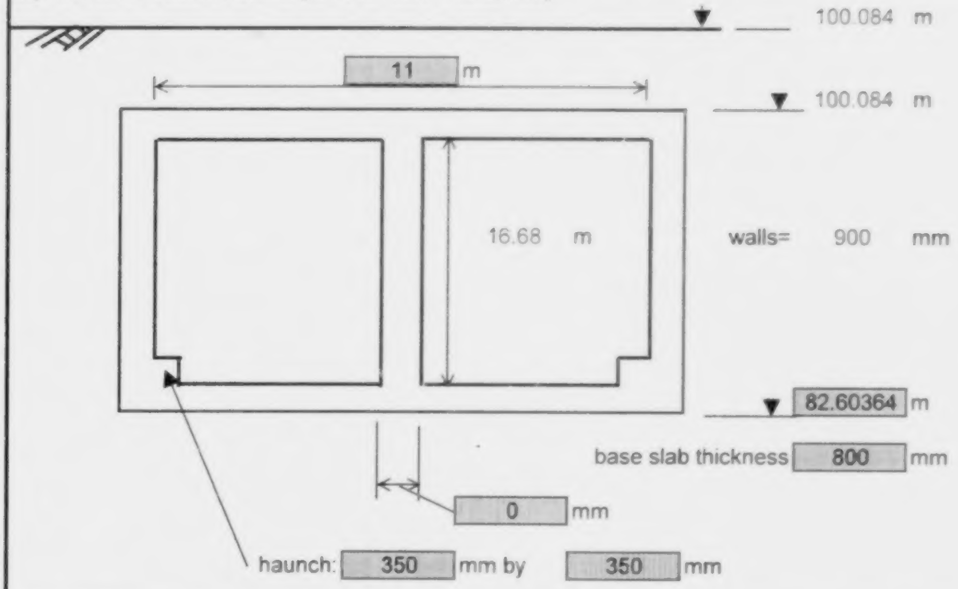
Section Cut and Cover
Length of section: 33.45455 m

Section 1

Input cross-section details (cut and cover solution)


100.084 m
11 m
100.084 m
16.68 m
walls= 900 mm
82.60364 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	7485.3	m3	
concrete=	1355.21	m3	
rebar=	162.6	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1116.044	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	1169.6	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	428.2182	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
D&B Highway Tunnel **Page 2 of 2**

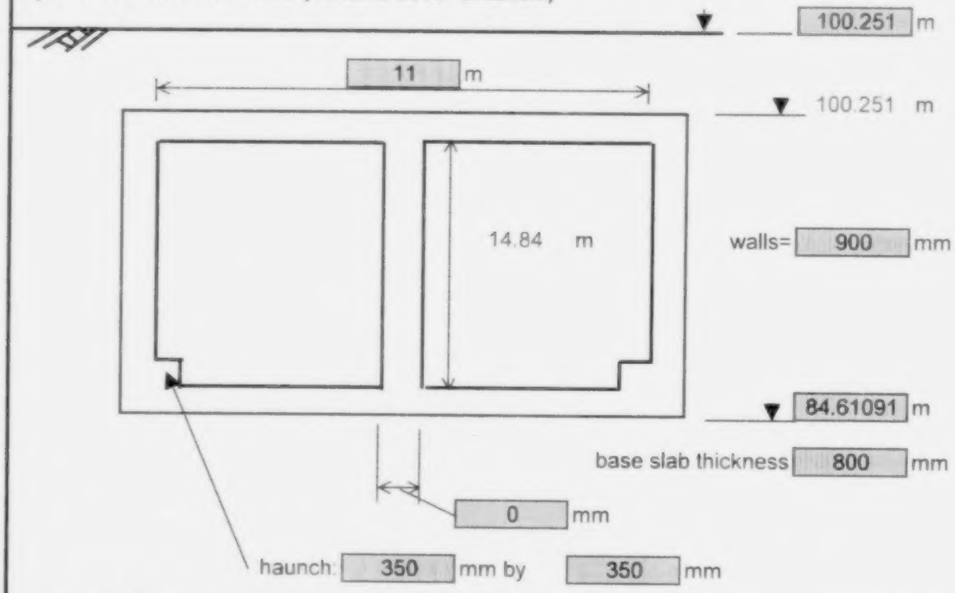
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	7485.3	60	449115.2
concrete	m3	1355.21	190.0	257489.9
rebar	tonnes	162.6	1600	260200.4
formwork/falsework	m2	1116.044	140	156246.1
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	1169.6	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	428.2182	30	12846.55
			Total	1135898

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
D&B Highway Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 33.45455 m **Section** 2

Input cross-section details (cut and cover solution)


100.251 m
11 m
100.251 m
14.84 m
walls= 900 mm
84.61091 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	6697.3	m3	
concrete=	1244.409	m3	
rebar=	149.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	992.9309	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	1046.5	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	428.2182	m2	

Newfoundland Fixed Link Pre-feasibility Study
South Approach
D&B Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 2 of 2

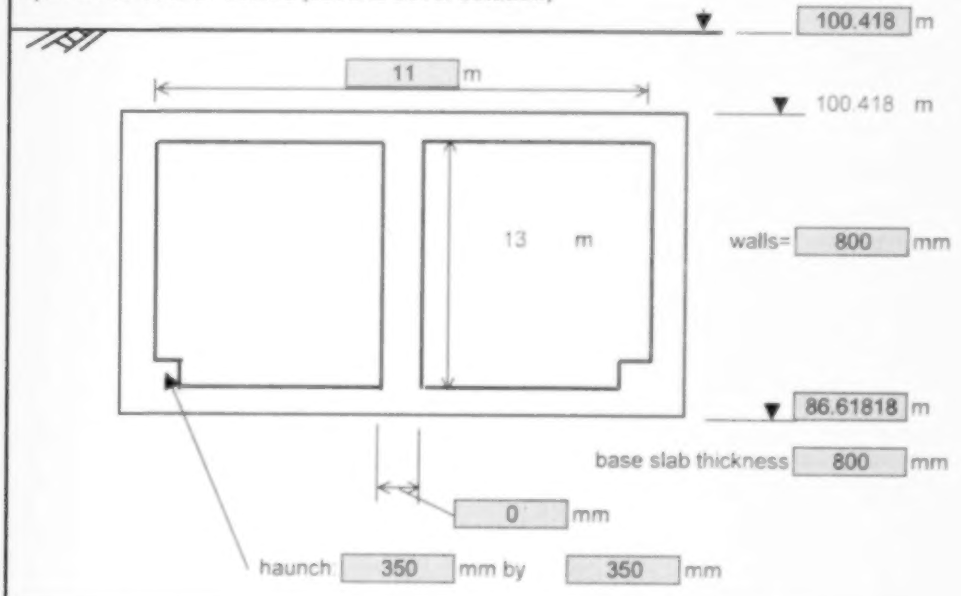
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	6697.3	60	401839.9
concrete	m3	1244.409	190.0	236437.7
rebar	tonnes	149.3	1600	238926.5
formwork/falsework	m2	992.9309	140	139010.3
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	1046.5	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	428.2182	30	12846.55
			Total	1029061

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
D&B Highway Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 33.45455 m **Section** 3

Input cross-section details (cut and cover solution)


100.418 m
11 m
100.418 m
13 m
walls= 800 mm
86.61818 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	5817.1	m3
concrete=	1041.273	m3
rebar=	125.0	tonnes (assume 0.12t/m3 of concrete)
formwork/falsework=	869.8182	m2
SP&L<=4.6m deep	0.0	m2
4.6<SP&L<=6.7m deep	0.0	m2
6.7<SP&L<=10.6m deep	0.0	m2
10.6<SP&L<=13.7m deep	0.0	m2
13.7<SP&L<=16.8m deep	923.3	m2
16.8<SP&L<=20.0m deep	0.0	m2
20<SP&L<=25m deep	0.0	m2
backfill=	0	m3
surface reinstatement=	421.5273	m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
D&B Highway Tunnel **Page 2 of 2**

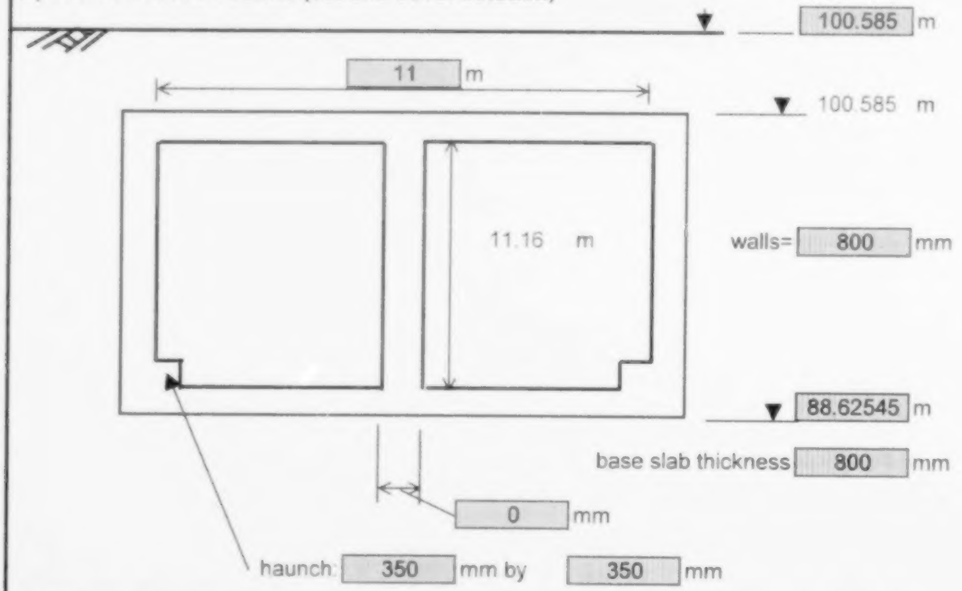
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	5817.1	60	349024.6
concrete	m3	1041.273	190.0	197841.8
rebar	tonnes	125.0	1600	199924.4
formwork/falsework	m2	869.8182	140	121774.5
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	923.3	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	421.5273	30	12645.82
			Total	881211.1

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
D&B Highway Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 33.45455 m **Section** 4

Input cross-section details (cut and cover solution)


100.585 m
11 m
100.585 m
11.16 m
walls= 800 mm
88.62545 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	5041.5	m3	
concrete=	942.7825	m3	
rebar=	113.1	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	746.7055	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	800.2	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	421.5273	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
D&B Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	5041.5	60	302488
concrete	m3	942.7825	190.0	179128.7
rebar	tonnes	113.1	1600	181014.2
formwork/falsework	m2	746.7055	140	104538.8
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	800.2	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	421.5273	30	12645.82
			Total	779815.5

Newfoundland Fixed Link Pre-feasibility Study
South Approach
D&B Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
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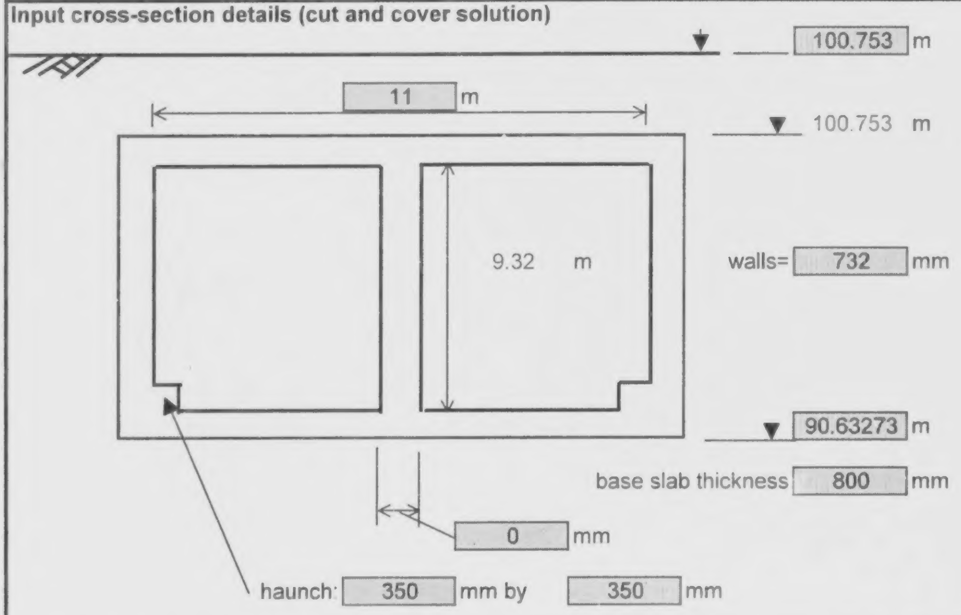
Section Cut and Cover
Length of section: 33.45455 m **Section** 5

Input cross-section details (cut and cover solution)


100.753 m
11 m
100.753 m
9.32 m
walls= 732 mm
90.63273 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	4219.8	m3	
concrete=	798.2482	m3	
rebar=	95.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	623.5927	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	677.1	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	416.9775	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
D&B Highway Tunnel **Page 2 of 2**

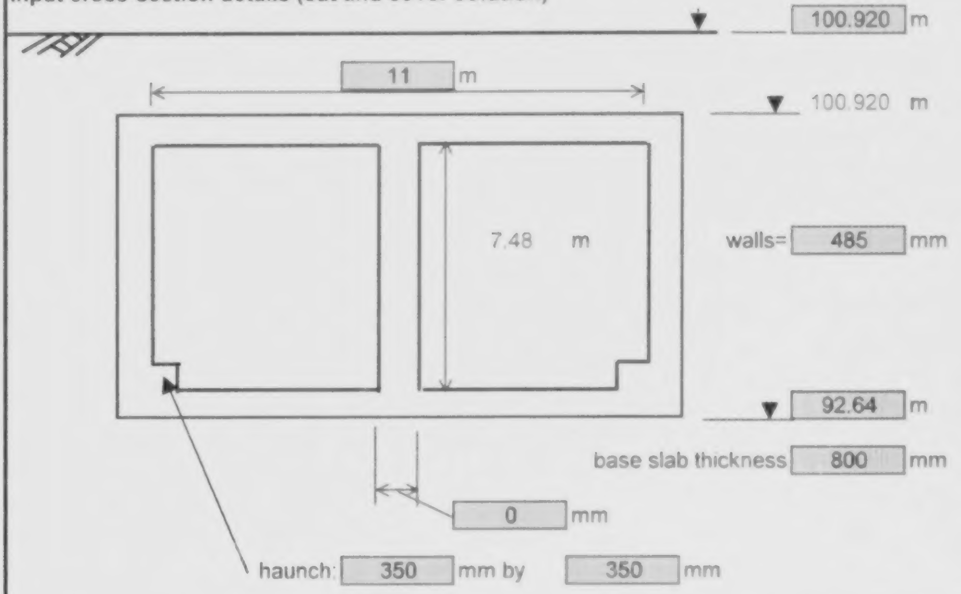
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	4219.8	60	253188.7
concrete	m3	798.2482	190.0	151667.2
rebar	tonnes	95.8	1600	153263.7
formwork/falsework	m2	623.5927	140	87302.98
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	677.1	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	416.9775	30	12509.32
			Total	657931.8

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
D&B Highway Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 33.45455 m **Section** **6**

Input cross-section details (cut and cover solution)


100.920 m
11 m
100.920 m
7.48 m
walls= 485 mm
92.64 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	3315.7	m3	
concrete=	571.2899	m3	
rebar=	68.6	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	500.48	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	554.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	400.4509	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
D&B Highway Tunnel **Page 2 of 2**

Calculated costs

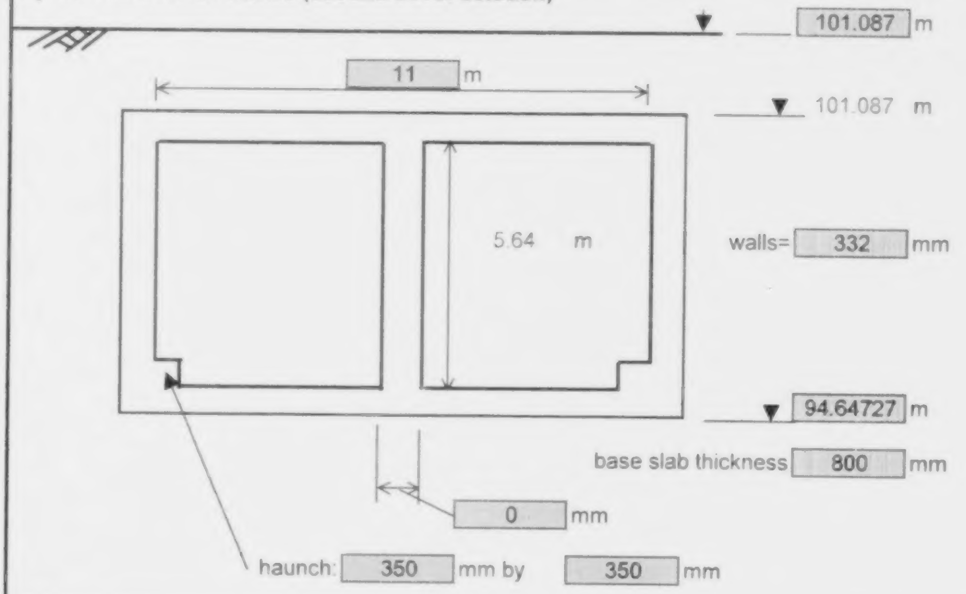
Item	Unit	Quantity	Rate	Cost
excavation	m3	3315.7	60	198944
concrete	m3	571.2899	190.0	108545.1
rebar	tonnes	68.6	1600	109687.7
formwork/falsework	m2	500.48	140	70067.2
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	554.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	400.4509	30	12013.53
			Total	499257.5

Newfoundland Fixed Link Pre-feasibility Study
South Approach
D&B Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 33.45455 m
Section 7

Input cross-section details (cut and cover solution)



101.087 m
11 m
101.087 m
5.64 m
walls= 332 mm
94.64727 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	2513.0	m3	
concrete=	445.6534	m3	
rebar=	53.5	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	377.3673	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	430.9	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	390.2138	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
D&B Highway Tunnel **Page 2 of 2**

Calculated costs

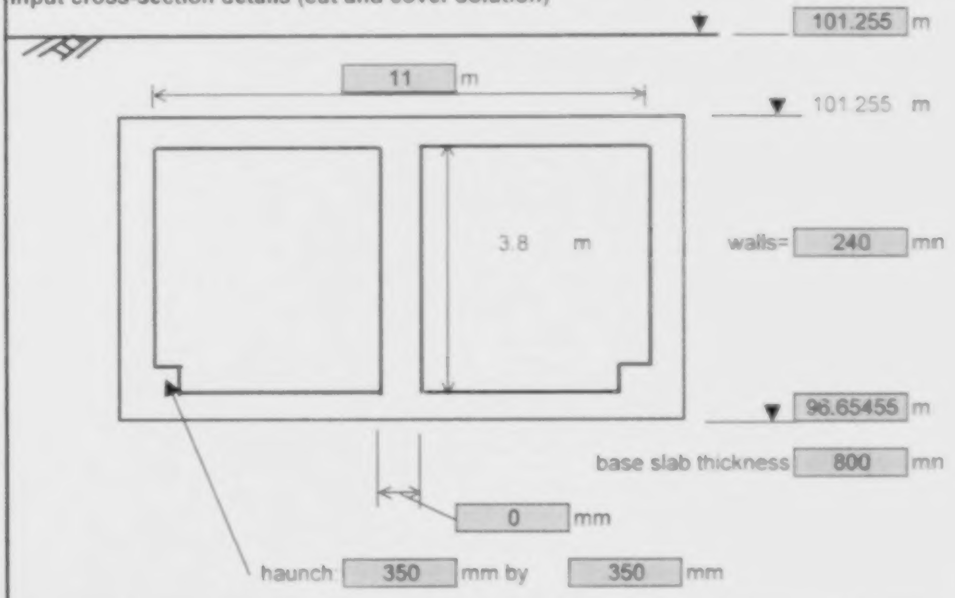
Item	Unit	Quantity	Rate	Cost
excavation	m3	2513.0	60	150778.6
concrete	m3	445.6534	190.0	84674.14
rebar	tonnes	53.5	1600	85565.44
formwork/falsework	m2	377.3673	140	52831.42
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	430.9	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	390.2138	30	11706.41
			Total	385556

Newfoundland Fixed Link Pre-feasibility Study
South Approach
D&B Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 33.45455 m
Section 8

Input cross-section details (cut and cover solution)


101.255 m
11 m
101.255 m
3.8 m
walls= 240 mn
96.65455 m
base slab thickness 800 mn
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	1766.7	m3	
concrete=	376.464	m3	
rebar=	45.2	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	254.2545	m2	
SP&L<=4.6m deep	307.8	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	384.0582	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
D&B Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	1766.7	60	106000.1
concrete	m3	376.464	190.0	71528.16
rebar	tonnes	45.2	1600	72281.09
formwork/falsework	m2	254.2545	140	35595.64
SP&L<=4.6m deep	m2	307.8	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	384.0582	30	11521.75
			Total	296926.7

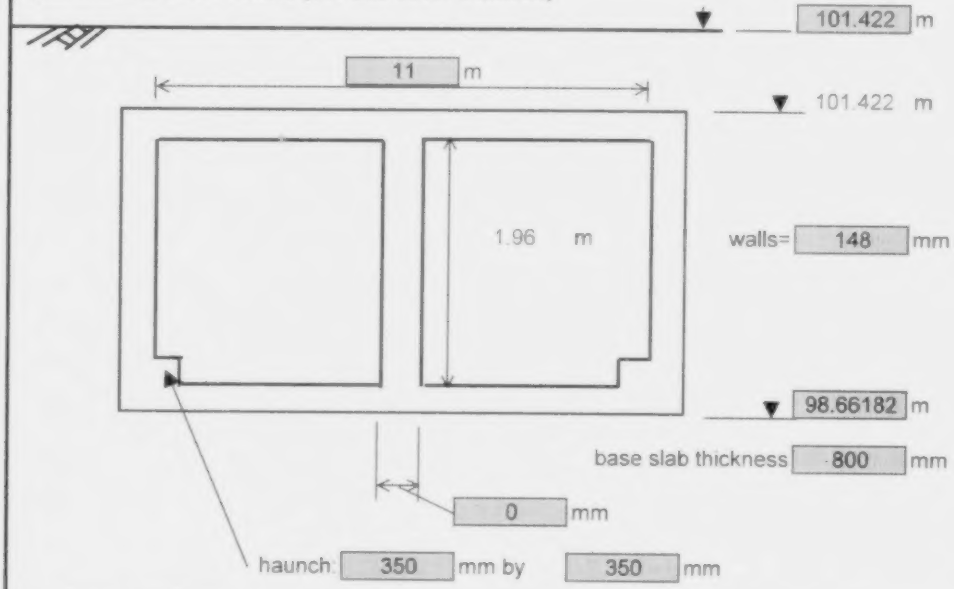
Newfoundland Fixed Link Pre-feasibility Study
South Approach
D&B Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 33.45455 m

Section 9

Input cross-section details (cut and cover solution)



walls= 148 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation= 1043.0 m3
concrete= 329.9274 m3
rebar= 39.6 tonnes (assume 0.12t/m3 of concrete)
formwork/falsework= 131.1418 m2
SP&L<=4.6m deep 184.7 m2
4.6<SP&L<=6.7m deep 0.0 m2
6.7<SP&L<=10.6m deep 0.0 m2
10.6<SP&L<=13.7m deep 0.0 m2
13.7<SP&L<=16.8m deep 0.0 m2
16.8<SP&L<=20.0m deep 0.0 m2
20<SP&L<=25m deep 0.0 m2
backfill= 0 m3
surface reinstatement= 377.9025 m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
D&B Highway Tunnel **Page 2 of 2**

Calculated costs

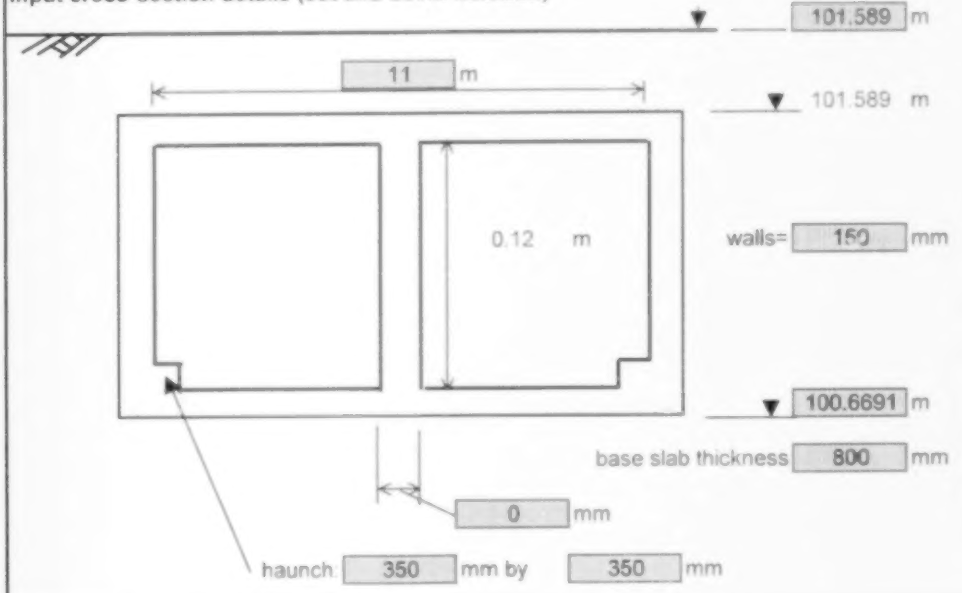
Item	Unit	Quantity	Rate	Cost
excavation	m3	1043.0	60	62580.66
concrete	m3	329.9274	190.0	62686.2
rebar	tonnes	39.6	1600	63346.06
formwork/falsework	m2	131.1418	140	18359.85
SP&L<=4.6m deep	m2	184.7	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	377.9025	30	11337.08
			Total	218309.9

Newfoundland Fixed Link Pre-feasibility Study
South Approach
D&B Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 33.45455 m
Section **10**

Input cross-section details (cut and cover solution)



101.589 m
11 m
101.589 m
0.12 m
walls= 150 mm
100.6691 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation= 347.8 m3
concrete= 311.8298 m3
rebar= 37.4 tonnes (assume 0.12t/m3 of concrete)
formwork/falsework= 8.029091 m2
SP&L<=4.6m deep 61.6 m2
4.6<SP&L<=6.7m deep 0.0 m2
6.7<SP&L<=10.6m deep 0.0 m2
10.6<SP&L<=13.7m deep 0.0 m2
13.7<SP&L<=16.8m deep 0.0 m2
16.8<SP&L<=20.0m deep 0.0 m2
20<SP&L<=25m deep 0.0 m2
backfill= 0 m3
surface reinstatement= 378.0364 m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
D&B Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	347.8	60	20867.61
concrete	m3	311.8298	190.0	59247.67
rebar	tonnes	37.4	1600	59871.33
formwork/falsework	m2	8.029091	140	1124.073
SP&L<=4.6m deep	m2	61.6	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	378.0364	30	11341.09
			Total	152451.8

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
D&B Highway Tunnel

Summary of Costs

Markup for adjacent 0 %

Section	**Cost**
1	1135898
2	1029061
3	881211.1
4	779815.5
5	657931.8
6	499257.5
7	385556
8	296926.7
9	218309.9
10	152451.8
Sub-total	6036419

Newfoundland Fixed Link Pre-feasibility Study
Highway Tunnel - North Vent Adit
Tunnel Final Liner Cost Estimate

Tunnel length= 600 m
Liner cross section area= 5.47 m2

Shift pattern

Shifts	Hours	Days
3	8	5

Advance rate= 30 m/day

Rebar ratio= 0.12 t/m3 of concrete

Concrete supply=$ 135 /m3

Rebar supply=$ 900 /t

Initial form set-up time= 4 weeks

Durations

Number of days= 40 days
Number of hours= 960 hours
Number of weeks= 8 weeks

Labour

Crew size 15
Average labour rate $ 47 /hour

Total labour cost=$ 676,800

Equipment

Form $ 1000000
Weekly cost of other equipment $ 15000 (see TED 2370)

Total equipment cost=$ 1,120,000

Materials

Concrete= 3279.8227 m3
Rebar= 393.57873

Concrete cost=$ 442,776
Rebar cost=$ 354,221

Total material cost=$ 796,997

Cost Summary

Labour	676,800
Equipment	1,120,000
Materials	796,997
Total	**2,593,797**

Newfoundland Fixed Link Pre-feasibility Study
Highway Tunnel - North Vent Adit
Tunnel Drill and Blast Cost Estimate

Drill & blast excavation @ $ 250 /m3

Tunnel length= 600 m
Tunnel excavated diameter= 6.5 m

Excavated volume= 19909.8 m3

Excavation cost=$ 4,977,461

Newfoundland Fixed Link Pre-feasibility Study
Highway Tunnel - North Vent Adit Shaft
Tunnel Drill and Blast Cost Estimate

shaft excavated diameter= 5.5 m
depth= 100 m
shaft final diameter= 6.1 m

From graph

unlined shaft cost=$ 17000 /m

Quantities

Concrete Base= 24 m3
Shotcrete= 173 m3
Rockbolts= 1728 m2
final cast in place liner= 547 m3

Direct Costs

				$ - Cost	
shaft excavation etc.	100	*	17000	1700000	
Concrete Base	24	*	150	3564	
Shotcrete	173	*	500	86394	
Rockbolts	1728	*	10	17279	
liner	547	*	600	327982	(includes steel & forms)
			Total Direct Cost=	**2135219**	

Newfoundland Fixed Link Pre-feasibility Study
Highway Tunnel - North Vent Adit
Tunnel Drill and Blast Cost Estimate

Drill & blast excavation @ $ 250 /m3

Tunnel length= 600 m
Tunnel excavated diameter= 6.5 m

Excavated volume= 19909.8 m3

Excavation cost=$ 4,977,461

Newfoundland Fixed Link Pre-feasibility Study
Highway Tunnel - North Vent Adit Shaft
Tunnel Drill and Blast Cost Estimate

shaft excavated diameter=	5.5	m
depth=	100	m
shaft final diameter=	6.1	m

From graph

unlined shaft cost=$ 17000 /m

Quantities

Concrete Base=	24	m3
Shotcrete=	173	m3
Rockbolts=	1728	m2
final cast in place liner=	547	m3

Direct Costs

				$ - Cost	
shaft excavation etc.	100	*	17000	1700000	
Concrete Base	24	*	150	3564	
Shotcrete	173	*	500	86394	
Rockbolts	1728	*	10	17279	
liner	547	*	600	327982	(includes steel & forms)
			Total Direct Cost=	2135219	

Newfoundland Fixed Link Pre-feasibility Study
Highway Tunnel - North Vent Adit
Summary

D&B Excavation	4,977,461
Liner	2,593,797
Shaft	2,135,219
	9,706,476

Newfoundland Fixed Link Pre-feasibility Study
Highway Tunnel - South Vent Adit
Tunnel Final Liner Cost Estimate

Tunnel length= 2000 m
Liner cross section area= 5.47 m2

Shift pattern

Shifts	Hours	Days
3	8	5

Advance rate= 30 m/day

Rebar ratio= 0.12 t/m3 of concrete

Concrete supply=$ 135 /m3

Rebar supply=$ 900 /t

Initial form set-up time= 4 weeks

Durations

Number of days= 87 days
Number of hours= 2080 hours
Number of weeks= 17 weeks

Labour

Crew size 15
Average labour rate $ 47 /hour

Total labour cost=$ 1,466,400

Equipment

Form $ 1000000
Weekly cost of other equipment $ 15000 (see TED 2370)

Total equipment cost=$ 1,260,000

Materials

Concrete= 10932.742 m3
Rebar= 1311.9291

Concrete cost=$ 1,475,920
Rebar cost=$ 1,180,736

Total material cost=$ 2,656,656

Cost Summary

Labour	1,466,400
Equipment	1,260,000
Materials	2,656,656
Total	**5,383,056**

Newfoundland Fixed Link Pre-feasibility Study
Highway Tunnel - South Vent Adit
Tunnel Final Liner Cost Estimate

Tunnel length= 2000 m
Liner cross section area= 5.47 m2

Shift pattern

Shifts	Hours	Days
3	8	5

Advance rate= 30 m/day

Rebar ratio= 0.12 t/m3 of concrete

Concrete supply=$ 135 /m3

Rebar supply=$ 900 /t

Initial form set-up time= 4 weeks

Durations

Number of days= 87 days
Number of hours= 2080 hours
Number of weeks= 17 weeks

Labour

Crew size 15
Average labour rate $ 47 /hour

Total labour cost=$ 1,466,400

Equipment

Form $ 1000000
Weekly cost of other equipment $ 15000 (see TED 2370)

Total equipment cost=$ 1,260,000

Materials

Concrete= 10932.742 m3
Rebar= 1311.9291

Concrete cost=$ 1,475,920
Rebar cost=$ 1,180,736

Total material cost=$ 2,656,656

Cost Summary

Labour	1,466,400
Equipment	1,260,000
Materials	2,656,656
Total	**5,383,056**

Newfoundland Fixed Link Pre-feasibility Study
Highway Tunnel - South Vent Adit
Tunnel Drill and Blast Cost Estimate

Drill & blast excavation @	$	250	/m3
Tunnel length=	2000	m	
Tunnel excavated diameter=	6.5	m	
Excavated volume=	66366.1	m3	
Excavation cost=$	16,591,536		

Newfoundland Fixed Link Pre-feasibility Study
Highway Tunnel - South Vent Adit Shaft
Tunnel Drill and Blast Cost Estimate

shaft excavated diameter= 5.5 m
depth= 0 m
shaft final diameter= 6.1 m

From graph

unlined shaft cost=$ 17000 /m

Quantities

Concrete Base=	24	m3
Shotcrete=	0	m3
Rockbolts=	0	m2
final cast in place liner=	0	m3

Direct Costs

				$ - Cost	
shaft excavation etc.	0	*	17000	0	
Concrete Base	24	*	150	3564	
Shotcrete	0	*	500	0	
Rockbolts	0	*	10	0	
liner	0	*	600	0	(includes steel & forms
			Total Direct Cost=	**3564**	

Newfoundland Fixed Link Pre-feasibility Study
Highway Tunnel - South Vent Adit
Tunnel Drill and Blast Cost Estimate

Drill & blast excavation @ $ 250 /m3

Tunnel length= 2000 m
Tunnel excavated diameter= 6.5 m

Excavated volume= 66366.1 m3

Excavation cost=$ 16,591,536

Newfoundland Fixed Link Pre-feasibility Study
Highway Tunnel - South Vent Adit Shaft
Tunnel Drill and Blast Cost Estimate

shaft excavated diameter= 5.5 m
depth= 0 m
shaft final diameter= 6.1 m

From graph

unlined shaft cost=$ 17000 /m

Quantities

Concrete Base= 24 m3
Shotcrete= 0 m3
Rockbolts= 0 m2
final cast in place liner= 0 m3

Direct Costs

				$ - Cost	
shaft excavation etc.	0	*	17000	0	
Concrete Base	24	*	150	3564	
Shotcrete	0	*	500	0	
Rockbolts	0	*	10	0	
liner	0	*	600	0	(includes steel & forms
			Total Direct Cost=	3564	

Newfoundland Fixed Link Pre-feasibility Study
Highway Tunnel - South Vent Adit
Summary

D&B Excavation	16,591,536
Liner	5,383,056
Shaft	3,564
	21,978,156

Newfoundland Fixed Link
Drill & Blast Highway Tunnel
Tunnel Lighting Cost

Fraser River Project - 2x3 lane tunnels

For 1550 m length of Theo Van Kooten calculated the tunnel lighting cost as follows:

732	m of threshold lighting costs $	661231.22	1260	lights				
818	m of interior lighting costs $	73151.75	139	lights				
1550	m of nightime circuit costs $	126767.31	241	lights				
1640	lights cost $	117280.47	to instal					
1550	m of conduit costs	101424.99						
		1079855.74	*		2	= $		2,159,711

Prorating for Newfoundland - assuming *50% for single lane tunnel

for 20248 m length of tunnel

732	m of threshold lighting costs $	661231.22	1260	lights				
19516	m of interior lighting costs $	1745268.4	3317	lights				
20248	m of nightime circuit costs $	1655990.00	3149	lights				
7726	lights cost $	552505.43	to instal					
20248	m of conduit costs	1324937.55						
		5939932.60	*		0.5	= $		2,969,966

Newfoundland Fixed Link Pre-feasibility Study
Drill & Blast Highway Tunnel - North Vehicle Holding Area

Area= 300 m by 600 m

Earthworks

Assume 0.5 m depth cleared over entire area

Spoil excavation and removal @ $ 30 /m3

Earthworks= 2,700,000

Surface

Assume surface @ 20 /m2

Surface= 3,600,000

Buildings etc.

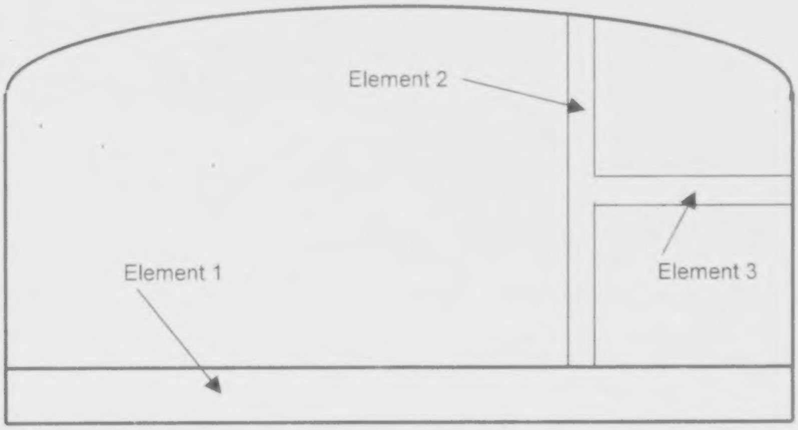
Public facilities building @	80000	See CJT estimate
Site maintenance building @	220000	See CJT estimate
Fire engines @	360000	See CJT estimate

Total cost **6,960,000**

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Lane Drill & Blast Highway Tunnel
Tunnel Structural Finishes

Page 1 of 2
Date: June 07, 2004
Calculation by: A.White

Tunnel length= 6500 m


Element 2
Element 1
Element 3

Assumed tunnel cross section
Zones 1, 3, and 5

Newfoundland Fixed Link Pre-feasibility Study
Drill & Blast Highway Tunnel - North Vehicle Holding Area

Area= 300 m by 600 m

Earthworks

Assume 0.5 m depth cleared over entire area

Spoil excavation and removal @ $ 30 /m3

Earthworks= 2,700,000

Surface

Assume surface @ 20 /m2

Surface= 3,600,000

Buildings etc.

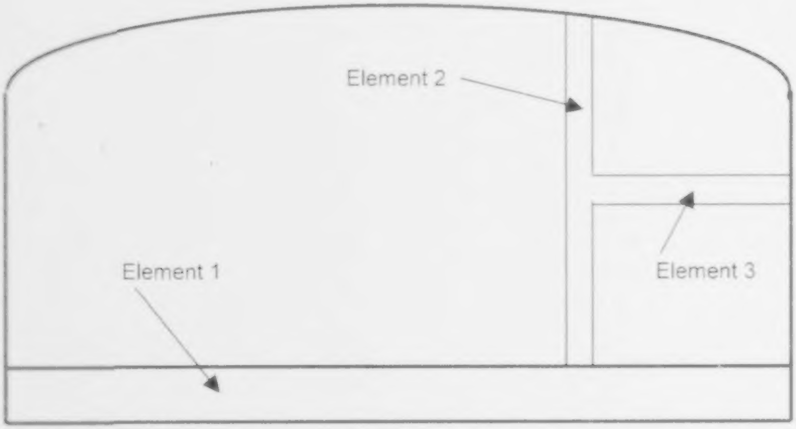
Public facilities building @	80000	See CJT estimate
Site maintenance building @	220000	See CJT estimate
Fire engines @	360000	See CJT estimate

Total cost **6,960,000**

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Lane Drill & Blast Highway Tunnel
Tunnel Structural Finishes

Page 1 of 2
Date: June 07, 2004
Calculation by: A.White

Tunnel length= 6500 m


Element 2
Element 1
Element 3

Assumed tunnel cross section
Zones 1, 3, and 5

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Lane Drill & Blast Highway Tunnel
Tunnel Structural Finishes

Page 2 of 2
Date: June 07, 2004
Calculation by: A.White

Quantity Take-off

Concrete

Element	Nr.	L(m)	b(m)	d(m)	Concrete Qty(m3)		Rebar Qty(m3)	
1	1	6500	8.8	0	0		0.0	
2	1	6500	0.3	5.4	10530		1263.6	
3	1	6500	1.8	0.3	3510		421.2	
					14040	m3	421	t

Formwork/falsework

Element	Nr.	L(m)	d(m)	Faces	Area(m2)	
1	1	6500	0	0	0	
2	2	6500	5.4	2	70200	
3	1	6500	1.8	1	11700	
					81900	m2

Rates

Concrete	m3	190
Formwork	m2	140
Reinforcement	t	1600

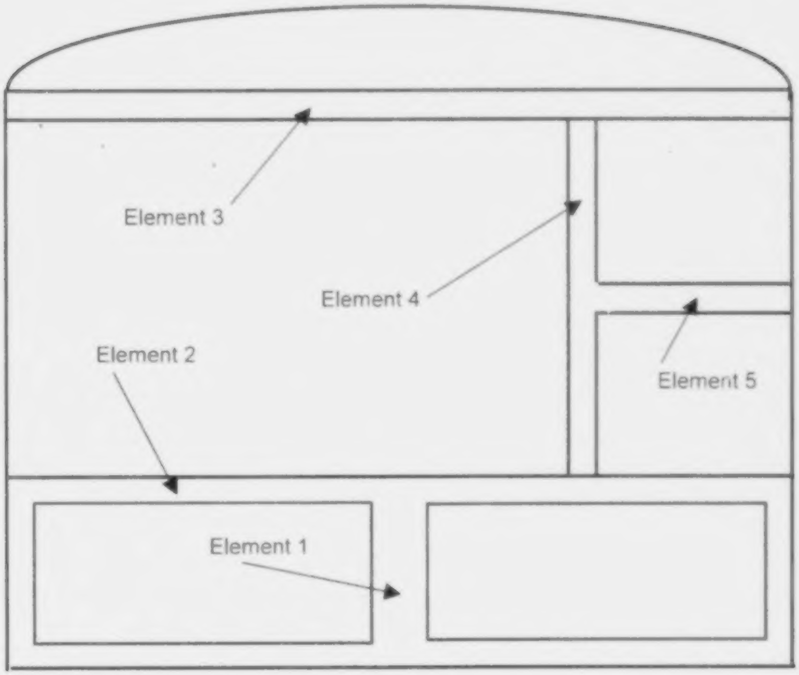
Costs

Concrete	m3	14040	m3	at	190	=	2667600
Formwork	m2	81900	m2	at	140	=	11466000
Reinforcement	t	421	t	at	1600	=	673920
						$	14807520

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Lane Drill & Blast Highway Tunnel
Tunnel Structural Finishes

Page 1 of 2
Date: June 07, 2004
Calculation by: A.White

Tunnel length= 13748 m


Element 3
Element 4
Element 2
Element 5
Element 1

Assumed tunnel cross section
Zones 1, 3, and 5

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Lane Drill & Blast Highway Tunnel
Tunnel Structural Finishes

Page 2 of 2
Date: June 07, 2004
Calculation by: A.White

Quantity Take-off

Concrete

Element	Nr.	L(m)	b(m)	d(m)	Concrete Qty(m3)		Rebar Qty(m3)	
1	1	6500	8.8	0	0		0.0	
2	1	6500	0.3	5.4	10530		1263.6	
3	1	6500	1.8	0.3	3510		421.2	
					14040	m3	421	t

Formwork/falsework

Element	Nr.	L(m)	d(m)	Faces	Area(m2)	
1	1	6500	0	0	0	
2	2	6500	5.4	2	70200	
3	1	6500	1.8	1	11700	
					81900	m2

Rates

Concrete	m3	190
Formwork	m2	140
Reinforcement	t	1600

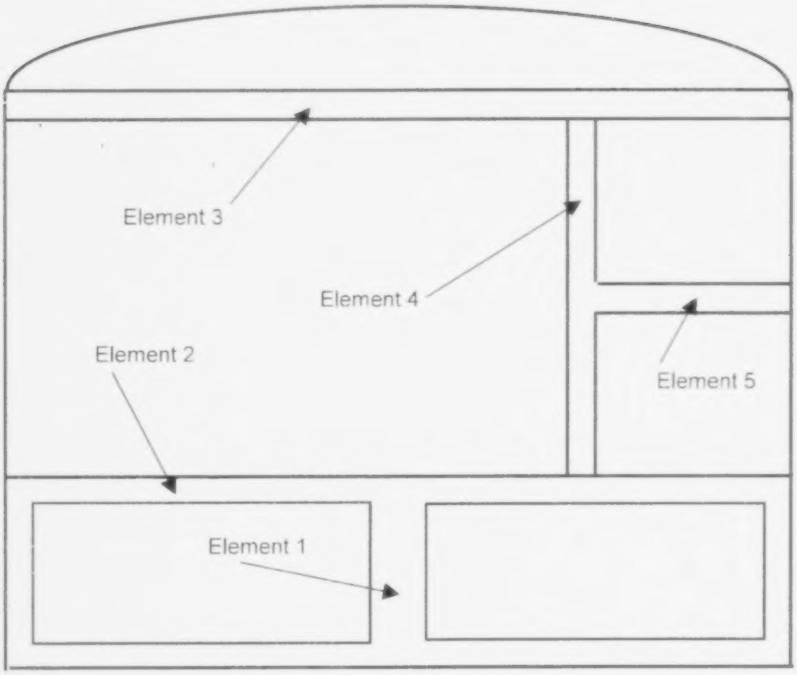
Costs

Concrete	m3	14040	m3	at	190	=	2667600
Formwork	m2	81900	m2	at	140	=	11466000
Reinforcement	t	421	t	at	1600	=	673920
						$	14807520

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Lane Drill & Blast Highway Tunnel
Tunnel Structural Finishes

Page 1 of 2
Date: June 07, 2004
Calculation by: A.White

Tunnel length= 13748 m


Element 3
Element 4
Element 2
Element 5
Element 1

Assumed tunnel cross section
Zones 1, 3, and 5

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Lane Drill & Blast Highway Tunnel
Tunnel Structural Finishes

Date: June 07, 2004
Calculation by: A.White

Quantity Take-off

Concrete

Element	Nr.	L(m)	b(m)	d(m)	Concrete Qty(m3)		Rebar Qty(m3)	
1	1	13748	0.5	1.5	10311		1237.3	
2	1	13748	9	0.5	61866		7423.9	
3	1	13748	8.6	0.5	59116		7094.0	
4	1	13748	0.3	5	20622		2474.6	
5	1	13748	1.8	0.3	7423.9		890.9	
					159339	m3	10459	t

Formwork/falsework

Element	Nr.	L(m)	d(m)	Faces	Area(m2)	
1	1	13748	1.5	2	41244	
2	2	13748	8.5	1	116858	
3	1	13748	8.6	1	118232.8	
4	1	13748	5	2	137480	
5	1	13748	1.8	1	24746.4	
					438561.2	m2

Rates

Concrete	m3	190
Formwork	m2	140
Reinforcement	t	1600

Costs

Concrete	m3	159339	m3	at	190	=	30274471
Formwork	m2	438561	m2	at	140	=	61398568
Reinforcement	t	10459	t	at	1600	=	16735165
						$	108408204

680.360656

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Lane Drill & Blast Highway Tunnel
Tunnel Structural Finishes

Page 2 of 2
Date: June 07, 2004
Calculation by: A.White

Quantity Take-off

Concrete

Element	Nr.	L(m)	b(m)	d(m)	Concrete Qty(m3)		Rebar Qty(m3)	
1	1	13748	0.5	1.5	10311		1237.3	
2	1	13748	9	0.5	61866		7423.9	
3	1	13748	8.6	0.5	59116		7094.0	
4	1	13748	0.3	5	20622		2474.6	
5	1	13748	1.8	0.3	7423.9		890.9	
					159339	m3	10459	t

Formwork/falsework

Element	Nr.	L(m)	d(m)	Faces	Area(m2)	
1	1	13748	1.5	2	41244	
2	2	13748	8.5	1	116858	
3	1	13748	8.6	1	118232.8	
4	1	13748	5	2	137480	
5	1	13748	1.8	1	24746.4	
					438561.2	m2

Rates

Concrete	m3	190
Formwork	m2	140
Reinforcement	t	1600

Costs

Concrete	m3	159339 m3	at	190	=	30274471
Formwork	m2	438561 m2	at	140	=	61398568
Reinforcement	t	10459 t	at	1600	=	16735165
					$	108408204

680.360656

Newfoundland Fixed Link
Drill & Blast Highway Tunnel - Tunnel Finishes
Cost Summary

	Zones 1, 3, and 5	Zones 2 and 4	Total	
Concrete	2,667,600	30,274,471	32,942,071	
Formwork	11,466,000	61,398,568	72,864,568	
Reinforcement	673,920	16,735,165	17,409,085	
			123,215,724	710.6714

Newfoundland Fixed Link Pre-feasibility Study
Drill & Blast Highway Tunnel - South Vehicle Holding Area

Area= 300 m by 600 m

Earthworks

Assume 0 m depth cleared over entire area

Spoil excavation and removal @ $ 30 /m3

Earthworks= 0

Surface

Assume surface @ 20 /m2

Surface= 3,600,000

Buildings etc.

Public facilities building @	80000	See CJT estimate
Site maintenance building @	220000	See CJT estimate
Fire engines @	360000	See CJT estimate

Total cost **4,260,000**

APPENDIX D (3)

IMMERSED TUBE HIGHWAY TUNNEL COSTS

Hatch Mott MacDonald

Newfoundland Fixed Link Pre-feasibility - Immersed Tube Highway Tunnel - Cost Summary

ITEM	UNIT	
MOBILIZATION & DEMOBILIZATION	LS	7,536,834
FABRICATION FACILITIES LEASE	LS	52,309,783
TUNNEL ELEMENT FABRICATION	LS	927,970,027
TUNNEL ELEMENT FINISHES	LS	94,194,981
MARINE DREDGE & BACKFILL	LS	743,334,442
UNIT TRANSPORT, PLACEMENT & CLOSURE	LS	247,961,957
NORTH DRILL AND BLAST TUNNEL	LS	69,969,983
NORTH APPROACH STRUCTURES	LS	5,533,384
SOUTH APPROACH STRUCTURES	LS	39,536,811
NORTH VENTILATION ADIT	LS	18,149,867
SOUTH VENTILATION ADIT	LS	0
ROAD FINISHES	LS	3,170,000
TUNNEL DRAINAGE	LS	7,370,000
NORTH VEHICLE HOLDING AREA	LS	6,960,000
SOUTH VEHICLE HOLDING AREA	LS	4,260,000
UTILITY DIVERSIONS	LS	1,000,000
MONITORING	LS	1,000,000
SUBTOTAL CIVIL		**$2,230,258,068**
CIVIL CONTINGENCIES		
CONTINGENCY	40%	$892,103,227
TOTAL CIVIL		**$3,122,361,295**
M&E AND FINISHING WORK		
VENTILATION EQUIPMENT	LS	$6,000,000
VENTILATION BUILDINGS x 2	LS	$2,000,000
FIRE SUPPRESSION SYSTEM	LS	$4,000,000
CONTROL CENTRE	LS	$4,000,000
SIGNALLING	LS	$0
LIGHTING	LS	$2,976,727
CCTV SYSTEM	LS	$1,077,800
GAS DETECTION	LS	$913,500
SUBSTATION, GENERATORS, UPS	LS	$4,202,000
SUBTOTAL M&E AND FINISHING		**$25,170,027**
CONTINGENCIES	20%	$5,034,005
TOTAL M&E AND FINISHING		**$30,204,032**
TOTAL CIVIL, M&E AND FINISHING		**$3,152,565,328**
ALLOWANCES		
CONTRACTOR OH	15%	$472,884,799
CONTRACTOR PROFIT	15%	$472,884,799
CONSTRUCTION TOTAL		**$4,099,000,000**
PRE-CONSTRUCTION AND SUPERVISION		
FEASIBILITY STUDY	LS	$11,000,000
ENVIRONMENTAL ASSESSMENT	LS	$4,000,000
DESIGN	5%	$204,950,000
CONSTRUCTION MANAGEMENT	10%	$409,900,000
OWNERS COSTS	2%	$81,980,000
PRE-CONSTRUCTION TOTAL		$711,830,000
GRAND TOTAL		**$4,810,830,000**

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Strait of Belle Isle Crossing

Preliminary Immersed Tube Tunnel Cost Estimate - Road Tunnel

Item	*Unit*	*Quantity*	*Rate*	*Total*
General Details				
Tunnel Length	18,000	metres		
Tunnel Element Length	150	metres	No. Elements =	120
The cross sectionof the tunnel element varies across three ventilation zones.				
Zone 1 from stations 0 to 1+800, and 16+200 to 18+000	3,600	metres	24	elements
Zone 2 from stations 1+800 to 6+150, and 11+850 to 16+200	8,700	metres	58	elements
Zone 3 from stations 6+150 to 11+850	5,700	metres	38	elements
1 *Miscellaneous*				
Mobilisation/demobilisation @ 3% of subtotal structure cost	ls	1	$5,547,109.65	$5,547,110
Fabrication facility lease (2 facilities assumed @ 5.5 yrs each)	year	11	$3,500,000.00	$38,500,000
2 *Tunnel Element Fabrication - Zone 1*				
Concrete				
Structural grade 4,000 psi placed by pump - slab on grade	m^3	94,968	$157.32	$14,940,366
Structural grade 4,000 psi placed by pump - elevated slab	m^3	80,640	$169.62	$13,678,157
Structural grade 4,000 psi placed by pump - walls	m^3	58,572	$175.31	$10,268,257
External Protection Layer, 2,500 psi, placed by pump	m^3	10,746	$153.34	$1,647,792
Keyed control joints transverse (at 20m centres approx)	m	10,161	$13.25	$134,633
Keyed control joints longitudinal (2 total at base/wall junction)	m	7,200	$13.25	$95,400
Curing, sprayed membrane, internal surfaces only	m	210,600	$1.32	$277,992
Formwork				
Walls, multiple use forms	m^2	146,700	$78.92	$11,577,564
Elevated Slab, multiple use forms	m^2	61,920	$74.27	$4,598,798
Reinforcement: grade 60 high yield				
Wall & Slab reinforcing, 150 kg/m^3	tonnes	35,127	$1,501.87	$52,756,187
Bending, cutting & splicing	tonnes	35,127	$270.44	$9,499,746
Waterproofing Membrane				
Steel skin plate, A36, 6 mm thick	tonnes	19,143	$3,132.11	$59,957,982
Shear connectors, 150 mm x 12 mm, including stud welding	each	812,880	$0.10	$81,288
Automated Welding	m	91,044	$14.86	$1,352,914
Tunnel Joints				
Structural Steel End Frames (2/element)				
Embedded steel beams, 180 kg/m	tonnes	480	$2,709.04	$1,300,339
Front plates, 20 mm thick	tonnes	216	$3,132.11	$676,536
Gina fabrication, installation	each	24	$29,128.00	$699,072
Omega fabrication, installation & testing	each	24	$36,693.00	$880,632
Joint concrete, shear keys, cover plates etc.	each	24	$20,000.00	$480,000
			Page Total	***$228,950,765***

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Strait of Belle Isle Crossing
Preliminary Immersed Tube Tunnel Cost Estimate - Road Tunnel

Item	*Unit*	*Quantity*	*Rate*	*Total*
			Toal Brought Forward	*$228,950,765*
Temporary Works Items (Per Element)				
Structural Steel Bulkheads (2/element)				
Support Columns, 250 kg/m	tonnes	936	$2,709.04	$2,535,661
Skin plate, 12 mm thick	tonnes	480	$3,132.11	$1,503,413
Plate siffening angle, 18 kg/m	tonnes	168	$3,174.03	$533,237
Embedded perimeter angle, 18 kg/m	tonnes	96	$3,174.03	$304,707
Welding	m	22,656	$14.86	$336,668
Field Welding Premium	m	22,656	$40.06	$907,599
Misc. Structural Steel				
Alignment & pulling brackets etc., 5 tonnes per element	tonnes	120	$3,132.11	$375,853
Ballast Tanks (2/element)				
Steel support columns, 100 kg/m	tonnes	672	$2,709.04	$1,820,475
Timber lagging, 150 mm deep	m^2	10,776	$60.40	$650,870
Membrane liner	m^2	10,776	$27.84	$300,004
3 Internal Structural & Civil Finish Works - Zone 1				
Ballast				
Road ballast concrete, 2,500 psi, placed by chute	m3	18,810	$140.06	$2,634,529
Road ballast reinforcement: welded wire fabric 6 x 6 x #4, 2.8kg/m^2	m^2	25,200	$9.36	$235,872
Deduct in excess of 4.5 tonnes	tonne	66	-$41.01	-$2,707
Emergency corridor sand/cement mix for HVDC cables	m3	4,410	$140.06	$617,665
Precast Divider for Emergency Egress Corridor & Vent Duct				
Panel fabrication, 8" thick, incuding reinformcement & lifting points	m^2	50,490	$196.98	$9,945,520
Panel setting, based upon max panel weight of 6 tons.	each	3,600	$285.70	$1,028,520
Seal and caulk panels	m	14,400	$5.48	$78,912
Sprayed fireproofing for precast panels	m^2	50,490	$20.77	$1,048,677
Roadway Surfacing				
Surface treatment, prepare & clean surface	km	3.6	$4,188.69	$15,079
Bituminous surface course, 75 mm thick	m3	1,890	$75.08	$141,901
4 Tunnel Element Fabrication - Zone 2				
Concrete				
Structural grade 4,000 psi placed by pump - slab on grade	m^3	169,563	$157.32	$26,675,651
Structural grade 4,000 psi placed by pump - elevated slab	m^3	149,205	$169.62	$25,308,152
Structural grade 4,000 psi placed by pump - walls	m^3	106,401	$175.31	$18,653,159
External Protection Layer, 2,500 psi, placed by pump	m^3	20,384	$153.34	$3,125,698
Keyed control joints transverse (at 20m centres approx)	m^2	20,097	$13.25	$266,285
Keyed control joints longitudinal (2 total at base/wall junction)	m	17,400	$13.25	$230,550
Curing, sprayed membrane, internal surfaces only	m	337,125	$1.32	$445,005
			Page Total	*$328,667,722*

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Strait of Belle Isle Crossing

Preliminary Immersed Tube Tunnel Cost Estimate - Road Tunnel

Item	*Unit*	*Quantity*	*Rate*	*Total*
			Toal Brought Forward	***$328,667,722***
Formwork				
Walls, multiple use forms	m^2	241,860	$78.92	$19,087,591
Elevated Slab, multiple use forms	m^2	117,885	$74.27	$8,755,319
Reinforcement: grade 60 high yield				
Wall & Slab reinforcing, 200 kg/m^3	tonnes	85,034	$1,501.87	$127,709,713
Bending, cutting & splicing	tonnes	85,034	$270.44	$22,996,541
Waterproofing Membrane				
Steel skin plate, A36, 6 mm thick	tonnes	19,140	$3,132.11	$59,948,585
Shear connectors, 150 mm x 12 mm, including stud welding	each	1,642,560	$0.10	$164,256
Automated Welding	m	186,528	$14.86	$2,771,806
Tunnel Joints				
Structural Steel End Frames (2/element)				
Embedded steel beams, 180 kg/m	tonnes	986	$2,709.04	$2,671,113
Front plates, 20 mm thick	tonnes	464	$3,132.11	$1,453,299
Gina fabrication, installation	each	58	$24,355.00	$1,412,590
Omega fabrication, installation & testing	each	58	$30,680.00	$1,779,440
Joint concrete, shear keys, cover plates etc.	each	58	$20,000.00	$1,160,000
Temporary Works Items (Per Element)				
Structural Steel Bulkheads (2/element)				
Support Columns, 250 kg/m	tonnes	1,682	$2,709.04	$4,556,605
Skin plate, 12 mm thick	tonnes	870	$3,132.11	$2,724,936
Plate siffening angle, 18 kg/m	tonnes	348	$3,174.03	$1,104,562
Embedded perimeter angle, 18 kg/m	tonnes	116	$3,174.03	$368,187
Welding	m	77,024	$14.86	$1,144,577
Field Welding Premium	m	77,024	$40.06	$3,085,581
Misc. Structural Steel				
Alignment & pulling brackets etc., 5 tonnes per element	tonnes	290	$3,132.11	$908,312
Ballast Tanks (2/element)				
Steel support columns, 100 kg/m	tonnes	1,508	$2,709.04	$4,085,232
Timber lagging, 150 mm deep	m^2	24,360	$60.40	$1,471,344
Membrane liner	m^2	24,360	$27.84	$678,182
5 *Internal Structural & Civil Finish Works - Zone 2*				
Ballast				
Road ballast concrete, 2,500 psi, placed by chute	m3	36,540	$140.06	$5,117,792
Road ballast reinforcement: welded wire fabric 6 x 6 x #4, 2.8kg/m^2	m^2	60,900	$9.36	$570,024
Deduct in excess of 4.5 tonnes	tonne	166	-$41.01	-$6,808
Emergency corridor sand/cement mix for HVDC cables	m3	10,658	$140.06	$1,492,689
			Page Total	***$605,879,194***

Strait of Belle Isle Crossing
Preliminary Immersed Tube Tunnel Cost Estimate - Road Tunnel

Item	Unit	Quantity	Rate	Total
			Toal Brought Forward	$605,879,194
Precast Divider for Emergency Egress Corridor				
Panel fabrication, 8" thick, incuding reinformcement & lifting points	m^2	137,460	$196.98	$27,076,871
Panel setting, based upon max panel weight of 6 tons.	each	13,050	$285.70	$3,728,385
Seal and caulk panels	m	52,200	$5.48	$286,056
Sprayed fireproofing for precast panels	m^2	167,040	$20.77	$3,469,421
Roadway Surfacing				
Surface treatment, prepare & clean surface	km	8.7	$4,188.69	$36,442
Bituminous surface course, 75 mm thick	m3	4,568	$75.08	$342,928
6 *Tunnel Element Fabrication - Zone 3*				
Concrete				
Structural grade 4,000 psi placed by pump - slab on grade	m^3	71,193	$157.32	$11,200,083
Structural grade 4,000 psi placed by pump - elevated slab	m^3	58,767	$169.62	$9,968,059
Structural grade 4,000 psi placed by pump - walls	m^3	55,475	$175.31	$9,725,366
External Protection Layer, 2,500 psi, placed by pump	m^3	9,320	$153.34	$1,429,052
Keyed control joints transverse (at 20m centres approx)	m^2	10,616	$13.25	$140,665
Keyed control joints longitudinal (2 total at base/wall junction)	m	11,400	$13.25	$151,050
Curing, sprayed membrane, internal surfaces only	m	169,005	$1.32	$223,087
Formwork				
Walls, multiple use forms	m^2	152,190	$78.92	$12,010,835
Elevated Slab, multiple use forms	m^2	52,440	$74.27	$3,894,719
Reinforcement: grade 60 high yield				
Wall & Slab reinforcing, 150 kg/m^3	tonnes	27,815	$1,501.87	$41,774,946
Bending, cutting & splicing	tonnes	27,815	$270.44	$7,522,366
Waterproofing Membrane				
Steel skin plate, A36, 6 mm thick	tonnes	9,975	$3,132.11	$31,242,797
Shear connectors, 150 mm x 12 mm, including stud welding	each	424,650	$0.10	$42,465
Automated Welding	m	99,465	$14.86	$1,478,050
Tunnel Joints				
Structural Steel End Frames (2/element)				
Embedded steel beams, 180 kg/m	tonnes	504	$2,709.04	$1,365,031
Front plates, 20 mm thick	tonnes	222	$3,132.11	$696,268
Gina fabrication, installation	each	38	$19,221.00	$730,398
Omega fabrication, installation & testing	each	38	$24,213.00	$920,094
Joint concrete, shear keys, cover plates etc.	each	38	$20,000.00	$760,000
			Page Total	$776,094,627

Item	Unit	Quantity	Rate	Total
			Toal Brought Forward	$776,094,627
Temporary Works Items (Per Element)				
Structural Steel Bulkheads (2/element)				
Support Columns, 250 kg/m	tonnes	749	$2,709.04	$2,027,987
Skin plate, 12 mm thick	tonnes	371	$3,132.11	$1,160,447
Plate siffening angle, 18 kg/m	tonnes	129	$3,174.03	$410,085
Embedded perimeter angle, 18 kg/m	tonnes	42	$3,174.03	$132,674
Welding	m	18,392	$14.86	$273,305
Field Welding Premium	m	18,392	$40.06	$736,784
Misc. Structural Steel				
Alignment & pulling brackets etc., 5 tonnes per element	tonnes	190	$3,132.11	$595,101
Ballast Tanks (2/element)				
Steel support columns, 100 kg/m	tonnes	836	$2,709.04	$2,264,757
Timber lagging, 150 mm deep	m^2	13,543	$60.40	$818,009
Membrane liner	m^2	13,543	$27.84	$377,043
7 *Internal Structural & Civil Finish Works - Zone 3*				
Ballast				
Road ballast concrete, 2,500 psi, placed by chute	m3	17,813	$140.06	$2,494,819
Road ballast reinforcement: welded wire fabric 6 x 6 x #4, 2.8kg/m^2	m^2	39,900	$9.36	$373,464
Deduct in excess of 4.5 tonnes	tonne	107	-$41.01	-$4,388
Emergency corridor sand/cement mix for HVDC cables	m3	3,563	$140.06	$498,964
Precast Divider for Emergency Egress Corridor				
Panel fabrication, 8" thick, incuding reinformcement & lifting points	m^2	32,063	$196.98	$6,315,671
Panel setting, based upon max panel weight of 6 tons.	each	2,850	$285.70	$814,245
Seal and caulk panels	m	11,400	$5.48	$62,472
Sprayed fireproofing for precast panels	m^2	32,063	$20.77	$665,938
Roadway Surfacing				
Surface treatment, prepare & clean surface	km	5.7	$4,188.69	$23,876
Bituminous surface course, 75 mm thick	m3	2,993	$75.08	$224,677
8 *Tunnel Transport & Placement*				
Element Transport: tug rental etc.	each	120	$500,000.00	$60,000,000
Element placement: barge/pontoons,divers, survey etc.	each	120	$1,000,000.00	$120,000,000
Tunnel Closure				
Underwater joint completion	each	1	$2,500,000.00	$2,500,000
			Page Total	**$978,860,556**

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Strait of Belle Isle Crossing

Preliminary Immersed Tube Tunnel Cost Estimate - Road Tunnel

Item	Unit	Quantity	Rate	Total
			Toal Brought Forward	*$978,860,556*
9 Marine Operation				
Dredging				
Mobilization/Demobilzation per season, 6 seasons, 2 vessels	each	24	$150,000.00	$3,600,000
Stage 1 bulk dredging of material	m3	5,255,299	$84.00	$441,445,116
Stage 2 fine tolerance dredging & additional trench cleaning	m3	788,295	$43.00	$33,896,685
Foundation and Backfill				
Bedded sand foundation	m3	263,385	$35.00	$9,218,475
Selected locking fill	m3	298,955	$35.00	$10,463,425
Backfill	m3	416,616	$35.00	$14,581,560
Rock armor protection	m3	664,488	$51.00	$33,888,888
Subtotal Structure Cost				*$1,525,954,705*
Tunnel MEP Systems	ls	10 % of structure cost		$152,595,470
Rail Systems	ls	15 % of structure cost		$228,893,206
Contingency on Tunnel Costs	ls	30% of subtotal structure cost		$457,786,411
"Soft" Costs				
Engineers design & construction supervision fee	ls	10% of construction cost		$236,522,979
Estimated Construction Cost				*$2,601,752,772*
Estimated Construction Cost per linear metre				*$144,542*

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: North Approach
Option: IT Highway Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient	0	%	+ sloping same way as track/road - sloping against track/road
Track/Road Gradient	6	%	
Ground elevation at portal	100	m	
Bottom of slab elevation at portal	81.6	m	
Total length=	306.6667	m	
Total Cost=$	5.5	M	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
IT Highway Tunnel

UNIT RATES

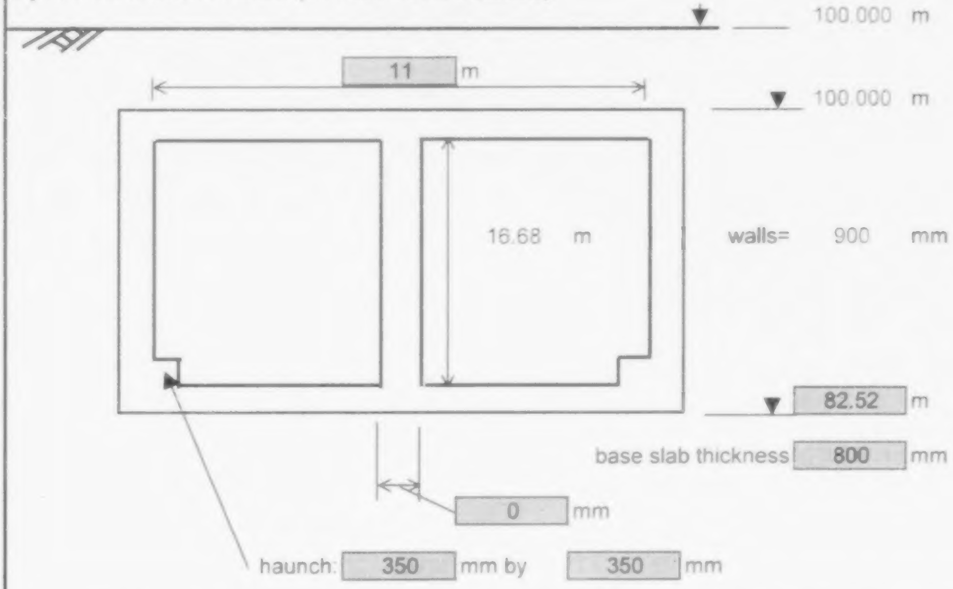
Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
IT Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 30.66667 m **Section** **1**

Input cross-section details (cut and cover solution)


100.000 m
11 m
100.000 m
16.68 m
walls= 900 mm
82.52 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation= 6861.5 m3
concrete= 1242.276 m3
rebar= 149.1 tonnes (assume 0.12t/m3 of concrete)
formwork/falsework= 1023.04 m2
SP&L<=4.6m deep 0.0 m2
4.6<SP&L<=6.7m deep 0.0 m2
6.7<SP&L<=10.6m deep 0.0 m2
10.6<SP&L<=13.7m deep 0.0 m2
13.7<SP&L<=16.8m deep 0.0 m2
16.8<SP&L<=20.0m deep 1072.1 m2
20<SP&L<=25m deep 0.0 m2
backfill= 0 m3
surface reinstatement= 392.5333 m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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IT Highway Tunnel

UNIT RATES

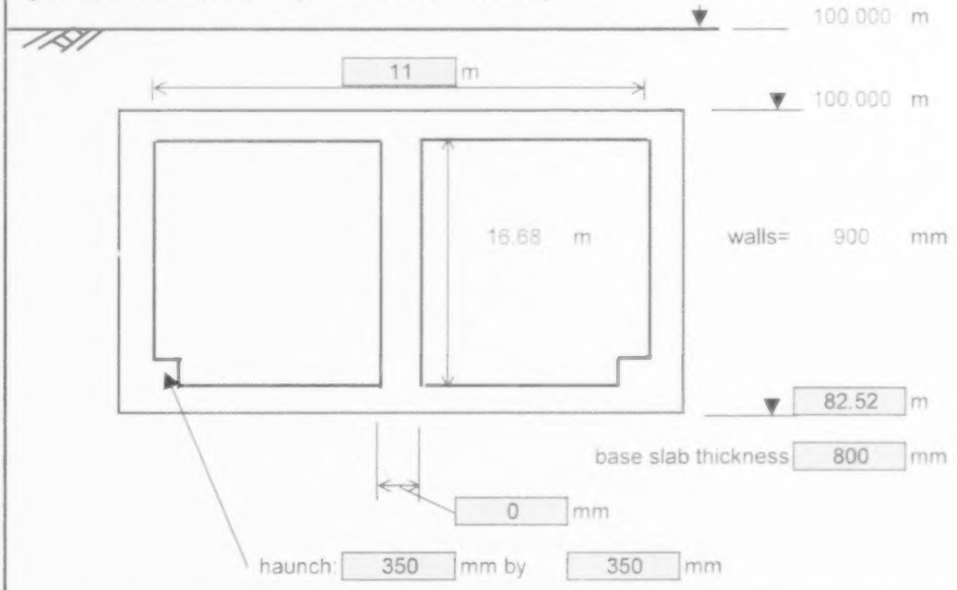
Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
IT Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 30.66667 m **Section 1**

Input cross-section details (cut and cover solution)



walls= 900 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	6861.5	m3	
concrete=	1242.276	m3	
rebar=	149.1	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1023.04	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	1072.1	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	392.5333	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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IT Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	6861.5	60	411689
concrete	m3	1242.276	190.0	236032.4
rebar	tonnes	149.1	1600	238517
formwork/falsework	m2	1023.04	140	143225.6
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	1072.1	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	392.5333	30	11776
			Total	1041240

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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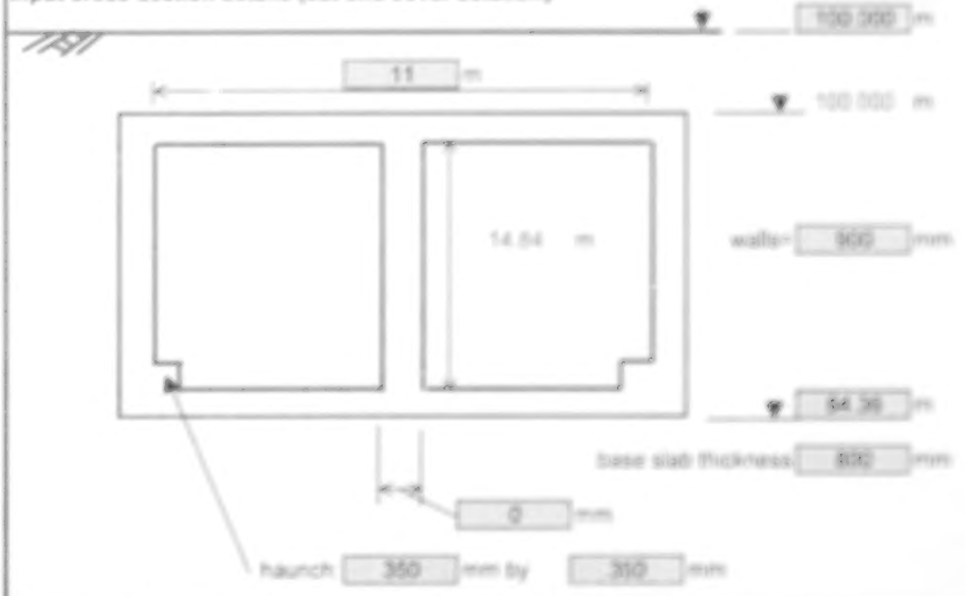
IT Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 30.66667 m **Section** 2

Input cross-section details (cut and cover solution)


100.300 m
11 m
100.000 m
14.64 m
walls= 900 mm
94.36 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	6139.2	m3	
concrete=	1140.708	m3	
rebar=	136.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	910.1867	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	959.3	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	392.5333	m2	

Newfoundland Fixed Link Pre-feasibility Study
North Approach
IT Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	6139.2	60	368353.3
concrete	m3	1140.708	190.0	216734.5
rebar	tonnes	136.9	1600	219015.9
formwork/falsework	m2	910.1867	140	127426.1
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	959.3	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	392.5333	30	11776
			Total	943305.9

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
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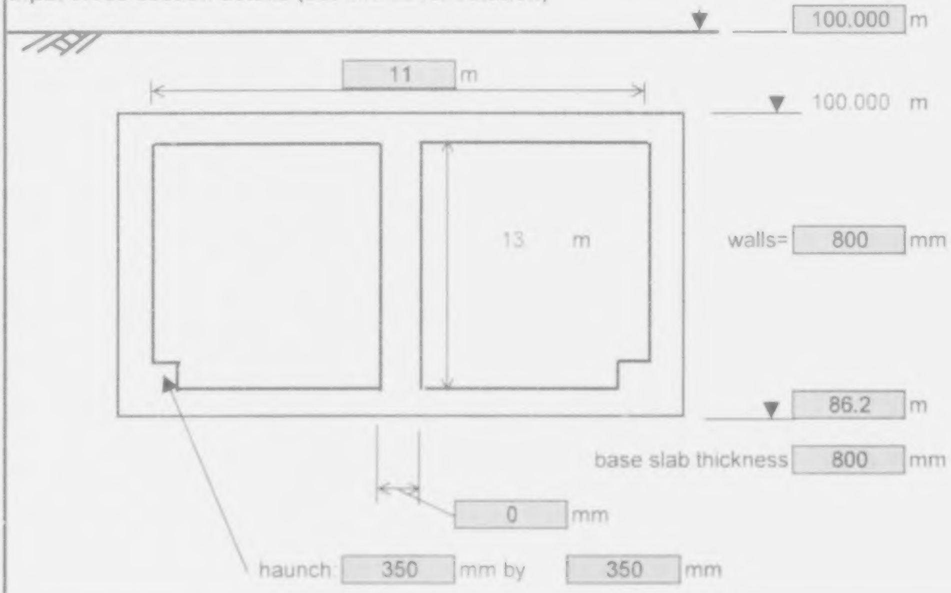
IT Highway Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 30.66667 m **Section 3**

Input cross-section details (cut and cover solution)



100.000 m
11 m
100.000 m
13 m
walls= 800 mm
86.2 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	5332.3	m3	
concrete=	954.5	m3	
rebar=	114.5	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	797.3333	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	846.4	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	386.4	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	5332.3	60	319939.2
concrete	m3	954.5	190.0	181355
rebar	tonnes	114.5	1600	183264
formwork/falsework	m2	797.3333	140	111626.7
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	846.4	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	386.4	30	11592

Total 807776.9

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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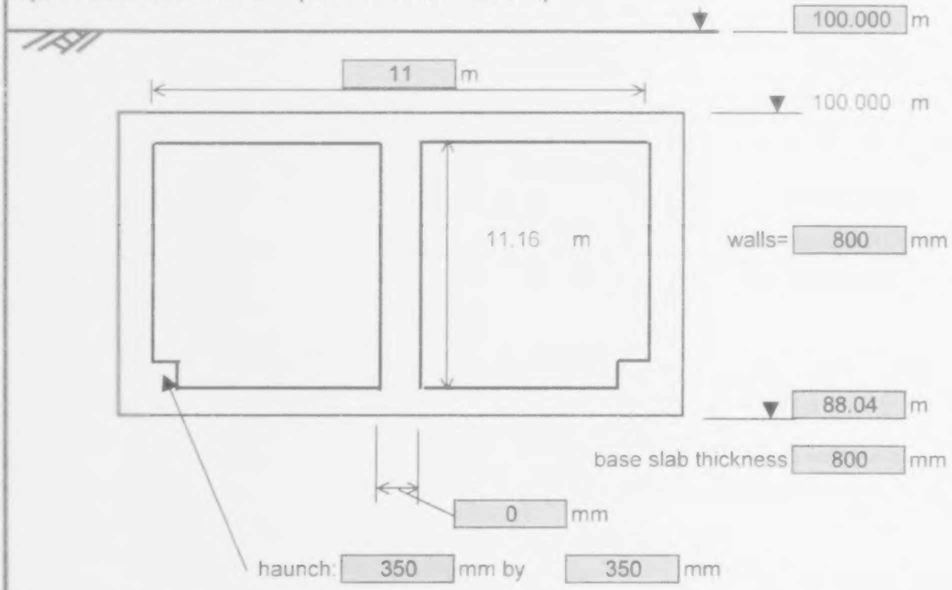
Section Cut and Cover
Length of section: 30.66667 m **Section 4**

Input cross-section details (cut and cover solution)



walls= 800 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	4621.3	m3	
concrete=	864.2173	m3	
rebar=	103.7	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	684.48	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	733.5	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
suface reinstatement=	386.4	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	4621.3	60	277280.6
concrete	m3	864.2173	190.0	164201.3
rebar	tonnes	103.7	1600	165929.7
formwork/falsework	m2	684.48	140	95827.2
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	733.5	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	386.4	30	11592
			Total	714830.9

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
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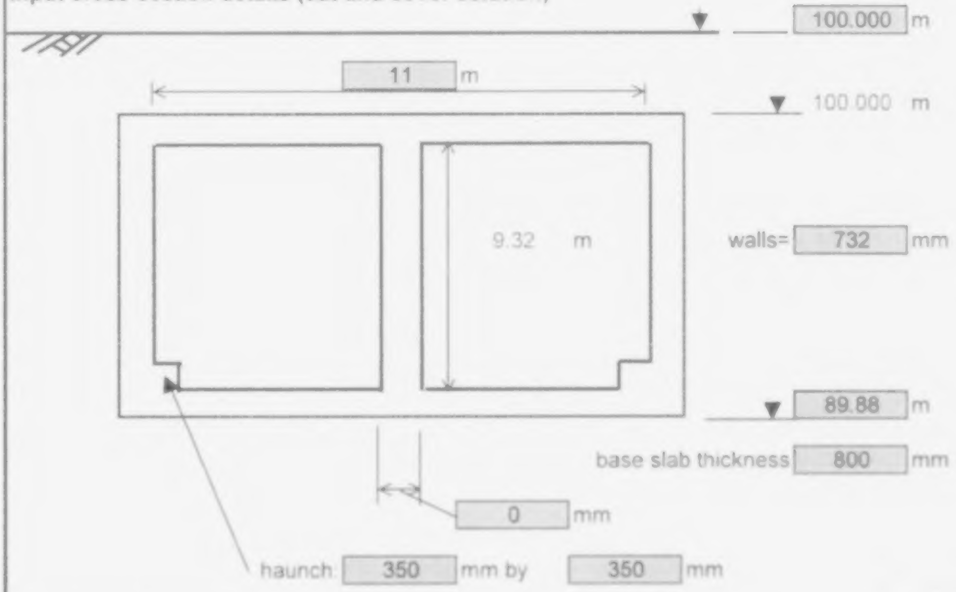
Section Cut and Cover
Length of section: 30.66667 m **Section** 5

Input cross-section details (cut and cover solution)


100.000 m
11 m
100.000 m
9.32 m
walls= 732 mm
89.88 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	3868.2	m3	
concrete=	731.7275	m3	
rebar=	87.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	571.6267	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	620.7	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	382.2293	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	3868.2	60	232089.7
concrete	m3	731.7275	190.0	139028.2
rebar	tonnes	87.8	1600	140491.7
formwork/falsework	m2	571.6267	140	80027.73
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	620.7	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	382.2293	30	11466.88
			Total	603104.2

Newfoundland Fixed Link Pre-feasibility Study
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IT Highway Tunnel

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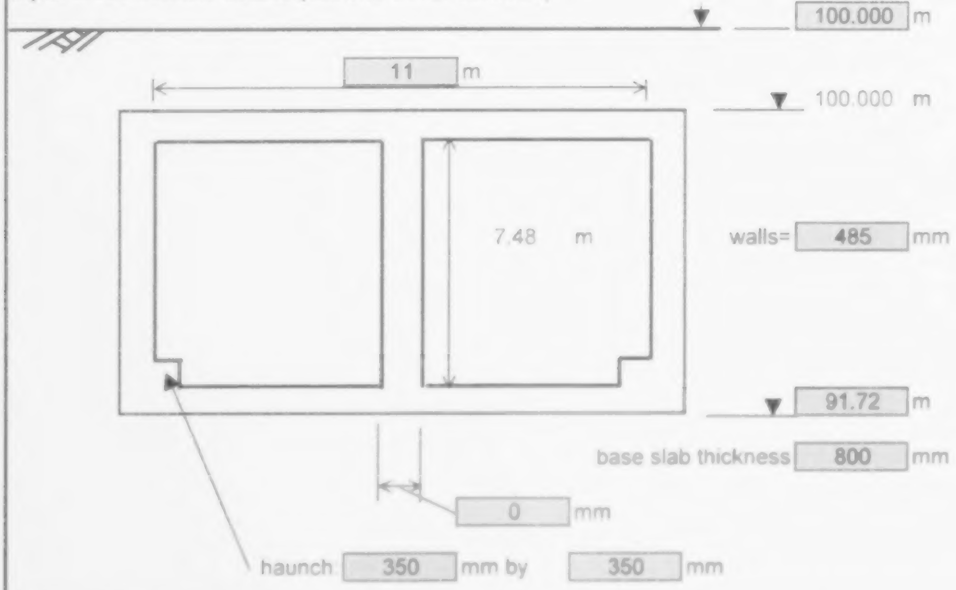
Section Cut and Cover
Length of section: 30.66667 m **Section** **6**

Input cross-section details (cut and cover solution)



100.000 m
11 m
100.000 m
7.48 m
walls= 485 mm
91.72 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	3039.4	m3	
concrete=	523.6824	m3	
rebar=	62.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	458.7733	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	507.8	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	367.08	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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IT Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	3039.4	60	182365.3
concrete	m3	523.6824	190.0	99499.66
rebar	tonnes	62.8	1600	100547
formwork/falsework	m2	458.7733	140	64228.27
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	507.8	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	367.08	30	11012.4
			Total	457652.7

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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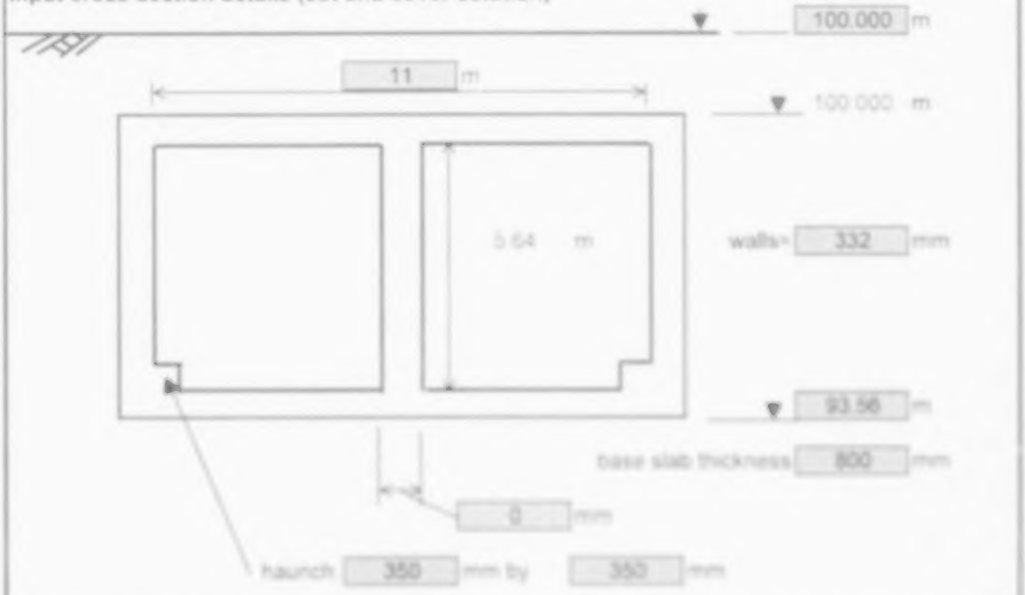
Section Cut and Cover
Length of section: 30.86667 m **Section** 7

Input cross-section details (cut and cover solution)


100.000 m
11 m
100.000 m
5.64 m
walls= 332 mm
93.56 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	2303.6	m3	
concrete=	408.5156	m3	
rebar=	49.0	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	345.92	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	395.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	357.338	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	2303.6	60	138213.7
concrete	m3	408.5156	190.0	77617.96
rebar	tonnes	49.0	1600	78434.99
formwork/falsework	m2	345.92	140	48428.8
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	395.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	357.696	30	10730.88
			Total	353426.4

Newfoundland Fixed Link Pre-feasibility Study
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IT Highway Tunnel

Date: 8-Jun-04
Calculations by: ANW
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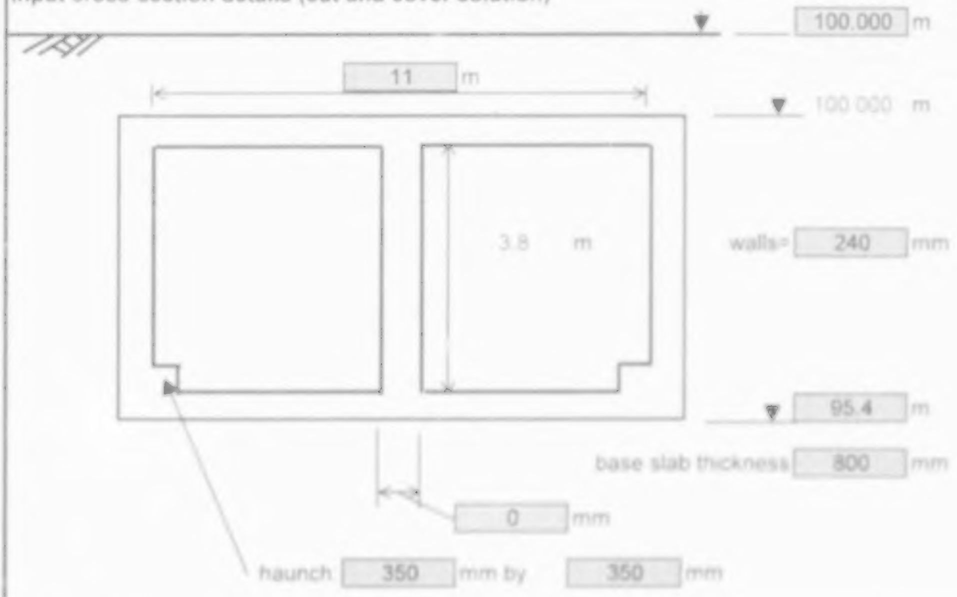
Section Cut and Cover
Length of section: 30.66667 m
Section 8

Input cross-section details (cut and cover solution)


100.000 m
11 m
100.000 m
3.8 m
walls= 240 mm
95.4 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation= 1619.4 m3
concrete= 345.092 m3
rebar= 41.4 tonnes (assume 0.12t/m3 of concrete)
formwork/falsework= 233.0667 m2
SP&L<=4.6m deep 282.1 m2
4.6<SP&L<=6.7m deep 0.0 m2
6.7<SP&L<=10.6m deep 0.0 m2
10.6<SP&L<=13.7m deep 0.0 m2
13.7<SP&L<=16.8m deep 0.0 m2
16.8<SP&L<=20.0m deep 0.0 m2
20<SP&L<=25m deep 0.0 m2
backfill= 0 m3
surface reinstatement= 352.0533 m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
IT Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	1619.4	60	97166.72
concrete	m3	345.092	190.0	65567.48
rebar	tonnes	41.4	1600	66257.66
formwork/falsework	m2	233.0667	140	32629.33
SP&L<=4.6m deep	m2	282.1	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	352.0533	30	10561.6
			Total	272182.8

Newfoundland Fixed Link Pre-feasibility Study
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Date: 9-Jun-04
Calculations by: AMR
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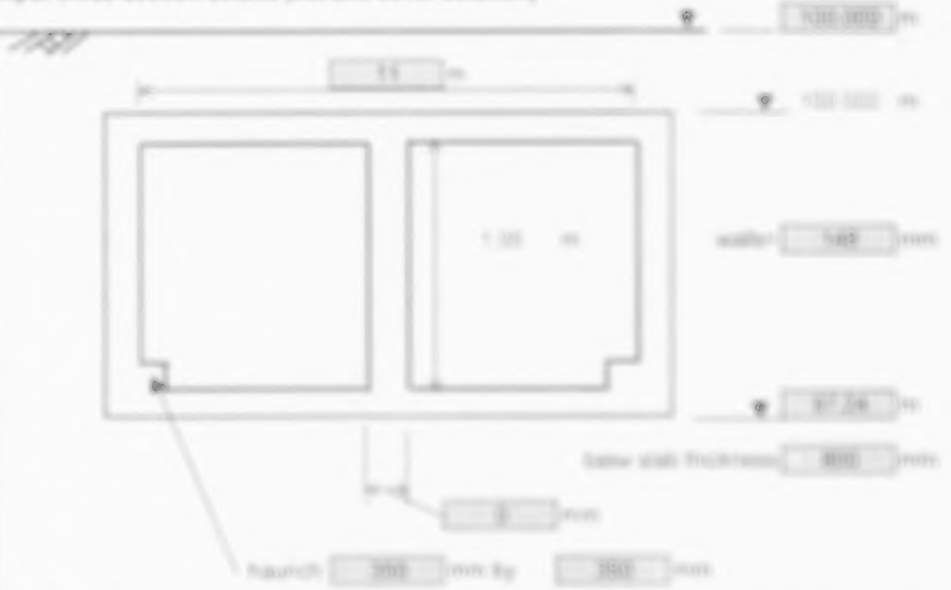
Section Cut and Cover
Length of section: 30.00567 m

Section 9

Input cross-section details (cut and cover solution)



100.000 m
11 m
100.000 m
1.35 m
walls= 500 mm
97.26 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation= 555.1 m3
concrete= 332.4334 m3
rebar= 39.3 tonnes (assume 0.12t/m3 of concrete)
formwork/falsework= 120.2133 m2
SP&L<=4.6m deep 103.3 m2
4.6<SP&L<=6.7m deep 0.0 m2
6.7<SP&L<=10.6m deep 0.0 m2
10.6<SP&L<=13.7m deep 0.0 m2
13.7<SP&L<=16.8m deep 0.0 m2
16.8<SP&L<=20.0m deep 0.0 m2
20<SP&L<=25m deep 0.0 m2
backfill= 0 m3
surface reinstatement= 145.4717 m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
IT Highway Tunnel **Page 2 of 2**

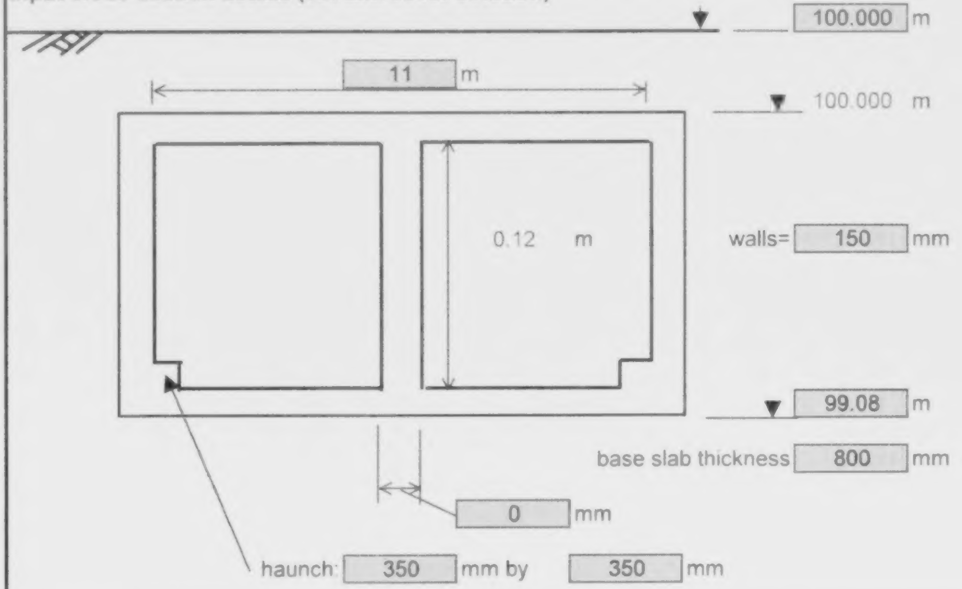
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	956.1	60	57365.61
concrete	m3	302.4334	190.0	57462.35
rebar	tonnes	36.3	1600	58067.22
formwork/falsework	m2	120.2133	140	16829.87
SP&L<=4.6m deep	m2	169.3	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	346.4107	30	10392.32
			Total	200117.4

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
IT Highway Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 30.66667 m **Section** **10**

Input cross-section details (cut and cover solution)


100.000 m
11 m
100.000 m
0.12 m
walls= 150 mm
99.08 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	318.8	m3	
concrete=	285.844	m3	
rebar=	34.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	7.36	m2	
SP&L<=4.6m deep	56.4	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	346.5333	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
IT Highway Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	318.8	60	19128.64
concrete	m3	285.844	190.0	54310.36
rebar	tonnes	34.3	1600	54882.05
formwork/falsework	m2	7.36	140	1030.4
SP&L<=4.6m deep	m2	56.4	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	346.5333	30	10396
			Total	139747.4

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
IT Highway Tunnel

Summary of Costs

Markup for adjacent 0 %

Section	Cost
1	1041240
2	943305.9
3	807776.9
4	714830.9
5	603104.2
6	457652.7
7	353426.4
8	272182.8
9	200117.4
10	139747.4
Sub-total	5533384

Newfoundland Fixed Link Pre-feasibility Study
Highway IT Tunnel - North Approach
Tunnel Final Liner Cost Estimate

Tunnel length= 2375 m
Liner cross section area= 17.20 m2

Shift pattern

Shifts	Hours	Days
3	8	5

Advance rate= 20 m/day

Rebar ratio= 0.12 t/m3 of concrete

Concrete supply=$ 135 /m3

Rebar supply=$ 900 /t

Initial form set-up time= 4 weeks

Durations

Number of days= 139 days
Number of hours= 3330 hours
Number of weeks= 28 weeks

Labour

Crew size 20
Average labour rate $ 47 /hour

Total labour cost=$ 3,130,200

Equipment

Form $ 1000000
Weekly cost of other equipment $ 15000 (see TED 2370)

Total equipment cost=$ 1,416,250

Materials

Concrete= 40850 m3
Rebar= 4902

Concrete cost=$ 5,514,750
Rebar cost=$ 4,411,800

Total material cost=$ 9,926,550

Cost Summary

Labour	3,130,200
Equipment	1,416,250
Materials	9,926,550
Total	**14,473,000**

Newfoundland Fixed Link Pre-feasibility Study
Highway IT Tunnel - North Approach
Tunnel Drill and Blast Cost Estimate

Drill & blast excavation @ $ 300 /m3

Tunnel length= 2375 m
Tunnel excavated diameter= 10 m

Excavated volume= 186532.1 m3

Excavation cost=$ 55,959,619

Newfoundland Fixed Link Pre-feasibility Study
Highway IT Tunnel - North Approach
Tunnel Final Liner Cost Estimate

Tunnel length=	2375	m
Liner cross section area=	17.20	m2

Shift pattern

Shifts	Hours	Days
3	8	5

Advance rate=	20	m/day
Rebar ratio=	0.12	t/m3 of concrete
Concrete supply=$	135	/m3
Rebar supply=$	900	/t
Initial form set-up time=	4	weeks

Durations

Number of days=	139	days
Number of hours=	3330	hours
Number of weeks=	28	weeks

Labour

Crew size	20	
Average labour rate $	47	/hour

Total labour cost=$ 3,130,200

Equipment

Form $	1000000	
Weekly cost of other equipment $	15000	(see TED 2370)

Total equipment cost=$ 1,416,250

Materials

Concrete=	40850	m3
Rebar=	4902	

Concrete cost=$ 5,514,750

Rebar cost=$ 4,411,800

Total material cost=$ 9,926,550

Cost Summary

Labour	3,130,200
Equipment	1,416,250
Materials	9,926,550
Total	**14,473,000**

Newfoundland Fixed Link Pre-feasibility Study
Highway IT Tunnel - North Approach
Tunnel Drill and Blast Cost Estimate

Drill & blast excavation @	$	300	/m3
Tunnel length=	2375	m	
Tunnel excavated diameter=	10	m	
Excavated volume=	186532.1	m3	
Excavation cost=$	55,959,619		

Newfoundland Fixed Link Pre-feasibility Study
Highway IT Tunnel - North Approach
Cost Summary

D&B Excavation	55,959,619
Liner	14,473,000
Shaft	0
	70,432,619

Newfoundland Fixed Link Pre-feasibility Study
Highway IT Tunnel - North Vent Adit
Tunnel Final Liner Cost Estimate

Tunnel length= 1500 m
Liner cross section area= 5.47 m2

Shift pattern

Shifts	Hours	Days
3	8	5

Advance rate= 30 m/day

Rebar ratio= 0.12 t/m3 of concrete

Concrete supply=$ 135 /m3

Rebar supply=$ 900 /t

Initial form set-up time= 4 weeks

Durations

Number of days= 70 days
Number of hours= 1680 hours
Number of weeks= 14 weeks

Labour

Crew size 15
Average labour rate $ 47 /hour

Total labour cost=$ 1,184,400

Equipment

Form $ 1000000
Weekly cost of other equipment $ 15000 (see TED 2370)

Total equipment cost=$ 1,210,000

Materials

Concrete= 8199.5568 m3
Rebar= 983.94682

Concrete cost=$ 1,106,940
Rebar cost=$ 885,552

Total material cost=$ 1,992,492

Cost Summary

Labour	1,184,400
Equipment	1,210,000
Materials	1,992,492
Total	**4,386,892**

Newfoundland Fixed Link Pre-feasibility Study
Highway IT Tunnel - North Vent Adit
Tunnel Drill and Blast Cost Estimate

Drill & blast excavation @	$	250	/m3
Tunnel length=	1500	m	
Tunnel excavated diameter=	6.5	m	
Excavated volume=	49774.6	m3	
Excavation cost=$	12,443,652		

Newfoundland Fixed Link Pre-feasibility Study
Highway IT Tunnel - North Vent Adit Shaft
Tunnel Drill and Blast Cost Estimate

shaft excavated diameter=	5.5	m
depth=	70	m
shaft final diameter=	6.1	m

From graph

unlined shaft cost=$ 17000 /m

Quantities

Concrete Base=	24	m3
Shotcrete=	121	m3
Rockbolts=	1210	m2
final cast in place liner=	383	m3

Direct Costs

				$ - Cost	
shaft excavation etc.	70	*	17000	1190000	
Concrete Base	24	*	150	3564	
Shotcrete	121	*	500	60476	
Rockbolts	1210	*	10	12095	
liner	383	*	600	229588	(includes steel & forms)
			Total Direct Cost=	**1495722**	

Newfoundland Fixed Link Pre-feasibility Study
Highway IT Tunnel
North Vent Adit

D&B Excavation	12,443,652
Liner	4,386,892
Shaft	1,495,722
	18,326,267

Newfoundland Fixed Link
Highway IT Option
Tunnel Lighting Costs

Fraser River Project - 2x3 lane tunnels

For 1550 m length of Theo Van Kooten calculated the tunnel lighting cost as follows:

732	m of threshold lighting costs $	661231.22	1260	lights			
818	m of interior lighting costs $	73151.75	139	lights			
1550	m of nightime circuit costs $	126767.31	241	lights			
1640	lights cost $	117280.47	to instal				
1550	m of conduit costs	101424.99					
		1079855.74	*	2	= $		2,159,711

Prorating for Newfoundland - assuming *50% for single lane tunnel

for 20300 m length of tunnel

732	m of threshold lighting costs $	661231.22	1260	lights			
19568	m of interior lighting costs $	1749918.6	3326	lights			
20300	m of nightime circuit costs $	1660242.83	3157	lights			
7743	lights cost $	553721.15	to instal				
20300	m of conduit costs	1328340.19					
		5953454.03	*	0.5	= $		2,976,727

Main Electrical Components for Novaroute
Single Immersed Tube Highway Tunnel Option

Length of each tunnel= 20300 m
Tunnel width= 9.5 m
Number of tunnels= 1

Item	Component	Unit	Qty	Unit Cost	Total Cost
	Lighting				
	Threshold + transition (1st 700m)	m2	7280	315	2293200
	Interior (balance)	m2	186200	120.00	22344000
				Lighting subtotal	0
	Substations, generators, UPS				
	Substations	Ea	2	1337000	2674000
	Emergency generator	Ea	1	955000	955000
	UPS (Battery system)	Ea	1	573000	573000
				Substations, generators, UPS subtotal	4202000
	CCTV system				
	Cameras (every 60m)	Each	338	3100	1047800
	Control station	Each	1	30000	30000
				CCTV system subtotal	1077800
	Provide power for gas detection, ventilation etc.				
	Power provision	m	20300	45	913500
				Power subtotal	913500
	Lane control system				
	Fibre optic display (every 200m)	Each	101	12500	0
				Lane control system subtotal	0

Lighting costed elsewhere.

Total Electrical 6193300

APPENDIX D (4)

HIGHWAY BRIDGE COSTS

Newfoundland Fixed Link
Bridge Option
Cost Estimate

Unit Costs

Suspension Bridge	$ 5,000	/m2	(Rate includes piers & deck)
Substructure Piers Protection	$ 260,000,000	/pier	

Quantities

Bridge length=	16,000	m
Bridge width=	10	m
Bridge Area=	160,000	m2
Bridge Piers	8	Nr.

Construction Costs

	Unit	Qty	$-Rate	$ - Cost
Suspension Bridge	m2	160,000	5,000	800,000,000
Substructure Piers Protection	Ea	8	260,000,000	2,080,000,000
			Sub-total	2,880,000,000
			25% Contingency	720,000,000
			Total	**3,600,000,000**

Pre-Construction and Supervision

	Unit	Qty	$-Rate	$ - Cost
Feasibility Study	LS	1	11,000,000	11,000,000
Environmental Assessment	LS	1	4,000,000	4,000,000
Design	5%	1	180,000,000	180,000,000
Construction Management	10%	1	360,000,000	360,000,000
Owners Costs	2%	1	72,000,000	72,000,000
				627,000,000

GRAND TOTAL **4,227,000,000**

Newfoundland Fixed Link
Bridge Option
Cost Estimate

Unit Costs

Suspension Bridge	$	5,000	/m2	(Rate includes piers & deck)
Substructure Piers Protection	$	260,000,000	/pier	

Quantities

Bridge length= 16,000 m
Bridge width= 10 m

Bridge Area= 160,000 m2

Bridge Piers 8 Nr.

Construction Costs

	Unit	Qty	$-Rate	$ - Cost
Suspension Bridge	m2	160,000	5,000	800,000,000
Substructure Piers Protection	Ea	8	260,000,000	2,080,000,000
			Sub-total	2,880,000,000
			25% Contingency	720,000,000
			Total	**3,600,000,000**

Pre-Construction and Supervision

	Unit	Qty	$-Rate	$ - Cost
Feasibility Study	LS	1	11,000,000	11,000,000
Environmental Assessment	LS	1	4,000,000	4,000,000
Design	5%	1	180,000,000	180,000,000
Construction Management	10%	1	360,000,000	360,000,000
Owners Costs	2%	1	72,000,000	72,000,000
				627,000,000

GRAND TOTAL **4,227,000,000**

APPENDIX D (5)

HIGHWAY CAUSEWAY COSTS

Newfoundland Fixed Link
Bridge/Causeway Option
Cost Estimate

Unit Costs

Suspension Bridge	$	5,000	/m2	
Bridge Approach	$	2,500	/m2	
Substructure Piers Protection	$	260,000,000	/pier	
Fill from shore	$	15	/m3	
Fill from barge	$	50	/m3	
Large armour stone from shore	$	100	/m3	wave zone armour stone
Large armour stone from barge	$	200	/m3	wave zone armour stone
Small armour stone from shore	$	50	/m3	iceberg zone armour stone
Small armour stone from barge	$	100	/m3	iceberg zone armour stone

Quantities

Bridge

Bridge length= 4,000 m
Bridge width= 10 m

Bridge Area= 40,000 m2

Approach

Approach length= 1,000 m
Approach width= 10 m

Approach area= 10,000 m2

Piers

Bridge Piers 2 Nr.

Rockfill from shore

Section	Length(m)	Top Width(m)	Slope (1:X)	Average Embankment Depth(m)	Calculated Volume (m3)	
1	3800	15	1.8	90	60,534,000	
3	4700	15	1.8	90	74,871,000	
				Total rockfill from shore	135,405,000	m3

Rockfill from barge

Section	Length(m)	Top Width(m)	Slope (1:X)	Average Embankment Depth(m)	Calculated Volume (m3)	
2	5600	15	1.8	80	71,232,000	
				Total rockfill from barge	71,232,000	m3

Large armour stone from shore

Section	Length(m)	Wave Protection Depth(m)	Armour Thickness(m)	Slope (1:X)	Calculated Volume (m3)	
1	3800	20	2.2	1.8	688,572	
3	4700	20	2.2	1.8	851,655	
			Large armour stone from shore		1,540,226	m3

Newfoundland Fixed Link
Bridge/Causeway Option
Cost Estimate

Quantities contd.

Large armour stone from barge

Section	Length(m)	Wave Protection Depth(m)	Armour Thickness(m)	Slope (1:X)	Calculated Volume (m3)
2	5600	20	2.2	1.8	1,014,737
			Large armour stone from barge		1,014,737 m3

Small armour stone from shore

Section	Length(m)	Iceberg Protection Depth(m)	Armour Thickness(m)	Slope (1:X)	Calculated Volume (m3)
1	3800	60	1	1.8	938,961
3	4700	60	1	1.8	1,161,347
			Small armour stone from shore		2,100,309 m3

Small armour stone from barge

Section	Length(m)	Wave Protection Depth(m)	Armour Thickness(m)	Slope (1:X)	Calculated Volume (m3)
2	5600	50	1	1.8	1,153,111
			Small armour stone from barge		1,118,000 m3

Construction Costs

	Unit	Qty	$-Rate	$ - Cost
Suspension Bridge	m2	40,000	5,000	200,000,000
Bridge approaches	m2	10,000	2,500	25,000,000
Substructure Piers Protection	Ea	2	260,000,000	520,000,000
Causeway Fill from Shore	m3	135,405,000	15	2,031,075,000
Causeway Fill in Channel	m3	71,232,000	50	3,561,600,000
Large armour stone from shore	m3	1,540,226	100	154,022,627
Large armour stone from barge	m3	1,014,737	200	202,947,461
Small armour stone from shore	m3	2,100,309	50	105,015,427
Small armour stone from barge	m3	1,118,000	100	111,800,000
			Sub-total	6,911,460,516
		25%	Contingency	1,727,865,129
			Total	**8,639,325,645**

Pre-Construction and Supervision

	Unit	Qty	$-Rate	$ - Cost
Feasibility Study	LS	1	11,000,000	11,000,000
Environmental Assessment	LS	1	4,000,000	4,000,000
Design	5%	1	431,966,282	431,966,282
Construction Management	10%	1	863,932,564	863,932,564
Owners Costs	2%	1	172,786,513	172,786,513
				1,483,685,360
			GRAND TOTAL	**10,123,011,004**

Newfoundland Fixed Link
Bridge/Causeway Option
Cost Estimate

Unit Costs

Suspension Bridge	$	5,000	/m2	
Bridge Approach	$	2,500	/m2	
Substructure Piers Protection	$	260,000,000	/pier	
Fill from shore	$	15	/m3	
Fill from barge	$	50	/m3	
Large armour stone from shore	$	100	/m3	wave zone armour stone
Large armour stone from barge	$	200	/m3	wave zone armour stone
Small armour stone from shore	$	50	/m3	iceberg zone armour stone
Small armour stone from barge	$	100	/m3	iceberg zone armour stone

Quantities

Bridge

Bridge length= 4,000 m
Bridge width= 10 m

Bridge Area= 40,000 m2

Approach

Approach length= 1,000 m
Approach width= 10 m

Approach area= 10,000 m2

Piers

Bridge Piers 2 Nr.

Rockfill from shore

Section	Length(m)	Top Width(m)	Slope (1:X)	Average Embankment Depth(m)	Calculated Volume (m3)	
1	3800	15	1.8	90	60,534,000	
3	4700	15	1.8	90	74,871,000	
				Total rockfill from shore	135,405,000	m3

Rockfill from barge

Section	Length(m)	Top Width(m)	Slope (1:X)	Average Embankment Depth(m)	Calculated Volume (m3)	
2	5600	15	1.8	80	71,232,000	
				Total rockfill from barge	71,232,000	m3

Large armour stone from shore

Section	Length(m)	Wave Protection Depth(m)	Armour Thickness(m)	Slope (1:X)	Calculated Volume (m3)	
1	3800	20	2.2	1.8	688,572	
3	4700	20	2.2	1.8	851,655	
				Large armour stone from shore	1,540,226	m3

Newfoundland Fixed Link
Bridge/Causeway Option
Cost Estimate

Quantities contd.

Large armour stone from barge

Section	Length(m)	Wave Protection Depth(m)	Armour Thickness(m)	Slope (1:X)	Calculated Volume (m3)
2	5600	20	2.2	1.8	1,014,737
			Large armour stone from barge		1,014,737 m3

Small armour stone from shore

Section	Length(m)	Iceberg Protection Depth(m)	Armour Thickness(m)	Slope (1:X)	Calculated Volume (m3)
1	3800	60	1	1.8	938,961
3	4700	60	1	1.8	1,161,347
			Small armour stone from shore		2,100,309 m3

Small armour stone from barge

Section	Length(m)	Wave Protection Depth(m)	Armour Thickness(m)	Slope (1:X)	Calculated Volume (m3)
2	5600	50	1	1.8	1,153,111
			Small armour stone from barge		1,118,000 m3

Construction Costs

	Unit	Qty	$-Rate	$ - Cost
Suspension Bridge	m2	40,000	5,000	200,000,000
Bridge approaches	m2	10,000	2,500	25,000,000
Substructure Piers Protection	Ea	2	260,000,000	520,000,000
Causeway Fill from Shore	m3	135,405,000	15	2,031,075,000
Causeway Fill in Channel	m3	71,232,000	50	3,561,600,000
Large armour stone from shore	m3	1,540,226	100	154,022,627
Large armour stone from barge	m3	1,014,737	200	202,947,461
Small armour stone from shore	m3	2,100,309	50	105,015,427
Small armour stone from barge	m3	1,118,000	100	111,800,000
			Sub-total	6,911,460,516
		25%	Contingency	1,727,865,129
			Total	**8,639,325,645**

Pre-Construction and Supervision

	Unit	Qty	$-Rate	$ - Cost
Feasibility Study	LS	1	11,000,000	11,000,000
Environmental Assessment	LS	1	4,000,000	4,000,000
Design	5%	1	431,966,282	431,966,282
Construction Management	10%	1	863,932,564	863,932,564
Owners Costs	2%	1	172,786,513	172,786,513
				1,483,685,360

GRAND TOTAL **10,123,011,004**

APPENDIX D (6)

BORED RAIL TUNNEL COSTS (1 TBM)

Newfoundland Fixed Link
Pre-feasibility Study
Preferred Fixed Link Option - TBM Bored Railway Tunnel
Basis of Estimate

Scope

Estimate includes:

- mobilisation of equipment and materials
- TBM bored tunnel excavation and lining
- TBM bored tunnel finishes
- north and south approaches to TBM bored rail tunnel
- north and south rail terminals including passenger facilities, maintenance facilities, tolling areas
- tunnel trackwork, drainage, ventilation, mechanical & electrical items
- shuttle trains, signalling, and OCS system
- allowances for indirect costs, contractor profit, and risk allowances

Estimate does not include:

- land purchase costs
- approach roads to the terminal areas (addressed separately)
- provision for bringing electrical power to the facility

Assumptions

Principal Assumptions:

- labour wages in accordance with Local 2003 Collective Agreement for Newfoundland & Labrador
- 7.5 metre internal diameter tunnel driven from Newfoundland side using an EPB type tunnel boring machine configured for rock
- tunnel approximately 26.3 kilometres in length
- 3 eight hour shifts 5 days per week for tunnelling operations
- tunnel lined with bolted precast concrete segmental tunnel liner
- average tunnelling advance rate of 81 metres per week
- tunnel drive encounters 14 faults each 100 metres wide where advance rate decreases by approximately 60%
- rail mounted loco and muck car system used for removal of tunnel spoil
- longitudinal system used for ventilation of the tunnel (permanent facility)

Costs

Cost assumptions

- All costs in 2004 Canadian dollars
- HST not included

Hatch Mott MacDonald

Newfoundland Fixed Link Pre-feasibility - TBM Bored Railway Tunnel - Cost Summary

BORED TUNNEL CONSTRUCTION COSTS		
ITEM	**UNIT**	**MAIN TUNNEL**
MOBILIZATION & DEMOBILIZATION	LS	8,000,000
TUNNELLING	LS	356,357,000
TUNNEL FINISHES	LS	75,539,979
NORTH APPROACH STRUCTURES	LS	7,770,000
SOUTH APPROACH STRUCTURES	LS	8,150,000
RAIL TRACK	LS	13,923,100
TUNNEL DRAINAGE	LS	7,820,000
UTILITY DIVERSIONS	LS	1,000,000
MONITORING	LS	1,000,000
SUBTOTAL CIVIL		**$479,560,079**
CIVIL CONTINGENCIES		
CONTINGENCY	40%	$191,824,032
TOTAL CIVIL		**$671,384,111**
M&E, ROLLING STOCK, RAIL HARDWARE AND FINISHING WORK		
ROLLING STOCK, TERMINALS, OCS, ETC	LS	$48,000,000
VENTILATION EQUIPMENT	LS	$3,000,000
VENTILATION SHAFTS AND BUILDINGS x 2	LS	$0
FIRE SUPPRESSION SYSTEM	LS	$2,000,000
CONTROL CENTRE	LS	$1,000,000
SIGNALLING	LS	$1,000,000
LIGHTING	LS	$1,000,000
CCTV SYSTEM	LS	$0
GAS DETECTION	LS	$900,000
SUBSTATION, GENERATORS, UPS	LS	$2,000,000
SUBTOTAL M&E AND FINISHING		**$58,900,000**
CONTINGENCIES	20%	$11,780,000
TOTAL M&E AND FINISHING		**$70,680,000**
TOTAL CIVIL, M&E AND FINISHING		**$742,064,111**
ALLOWANCES		
CONTRACTOR OH	15%	$111,309,617
CONTRACTOR PROFIT	15%	$111,309,617
CONSTRUCTION TOTAL		**$965,000,000**
PRE-CONSTRUCTION AND SUPERVISION		
FEASIBILITY STUDY	LS	$11,000,000
ENVIRONMENTAL ASSESSMENT	LS	$4,000,000
DESIGN	5%	$48,250,000
CONSTRUCTION MANAGEMENT	10%	$96,500,000
OWNERS COSTS	2%	$19,300,000
PRE-CONSTRUCTION TOTAL		$179,050,000
GRAND TOTAL		**$1,144,050,000**

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Newfoundland Fixed Link Pre-feasibility - TBM Bored Railway Tunnel - Civil Costs

ITEM	UNIT	QTY	RATE	TOTAL
MOBILIZATION	LS	1.00	$8,000,000	$8,000,000
TUNNELLING				
- TBM launch shaft	LS	1.00	$0	$0
- Set-up TBM	LS	1.00	$737,000	$737,000
- Tunnel drive	LS	1.00	$350,470,000	$350,470,000
- TBM maintenance	LS	1.00	$960,000	$960,000
- Remove TBM	LS	1.00	$406,000	$406,000
- Clean tunnel	LS	1.00	$3,784,000	$3,784,000
- Structural finishes	LS	1.00	$75,539,979	$75,539,979
- TBM reception shaft	LS	1.00	$0	$0
NORTH APPROACH STRUCTURES				
- Cut and cover approach	LS	1.00	$7,770,000	$7,770,000
SOUTH APPROACH STRUCTURES				
- cut and cover approach	LS	1.00	$8,150,000	$8,150,000
DRAINAGE				
Drainage sumps and piping	LS	1.00	$7,820,000	$7,820,000
RAIL TRACK				
- bored tunnel	m2	40,050.00	$20	$801,000
- north approach	m2	31,150.00	$20	$623,000
- south approach	m2	1,602.00	$30	$48,060
SUB-TOTAL				**$465,109,039**

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Detailed Cost Estimate Report

Project:	Newfoundland Fixed Link Pre-feasibility Study	**Project Number:**	213789
Estimate Description:	Set-up TBM	**Parent Estimate ID:**	1563
Tunnel Name:	Single Rail Bored	**Project Phase:**	Conceptual
Construction Activity:	Erect TBM Only	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	May 31, 2004
Estimate Definition ID:	2636	**Tunnel Characteristics ID:**	843

Tunnel Characteristics

Finished Diameter: 7.5 m

Activity Details

Shift Arrangement	3 - 8 hour shifts x 7 days per week
Duration of Activity	4.5 Weeks
Total Number of Shifts	94.5

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor					
Pit boss	52.29	$/hr	756.00	1.00	39,531
Tunnel miner	48.89	$/hr	756.00	2.00	73,922
Shaft bottom	48.44	$/hr	756.00	3.00	109,862
Tunnel fitter	49.34	$/hr	756.00	1.00	37,301
Tunnel electrician	49.34	$/hr	756.00	1.00	37,301
Shaft top	47.99	$/hr	756.00	1.00	36,280
Crane operator	49.34	$/hr	756.00	2.00	74,602
Surface laborer	47.99	$/hr	756.00	1.00	36,280
Equipment laborer	48.44	$/hr	756.00	1.00	36,621
				13.00	$481,701
Plant					
Loco	5,000.00	$/wk	4.50	1.00	22,500
Muck cars & grout cars	1,900.00	$/wk	4.50	6.00	51,300
Flat cars	310.00	$/wk	4.50	2.00	2,790
Transformers & switchgear - LV	750.00	$/wk	4.50	1.00	3,375
Small tools	2,600.00	$/wk	4.50	1.00	11,700
Shaft crane	9,000.00	$/wk	4.50	1.00	40,500
Erection crane	10,000.00	$/wk	4.50	1.00	45,000
Compressors	950.00	$/wk	4.50	1.00	4,275
Generators	2,000.00	$/wk	4.50	1.00	9,000
Transformers & switchgear - HV	5,200.00	$/wk	4.50	1.00	23,400
Loaders	2,300.00	$/wk	4.50	1.00	10,350
					$224,190
Consumables					
Electrical power	0.00	$/kwh	756.00	300.00	0
Gas oil	0.00	$/L	0.00	1.00	0

Estimate Definition ID: 2636

Estimated by: ____________

Checked by: ____________

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Lubrication materials	0.00	$/wk	4.50	1.00	0
Filters etc.	0.00	$/wk	4.50	1.00	0
Hydraulic oil	0.00	$/L	0.00	1.00	0
Other consumables	0.00	$/wk	4.50	1.00	0
					$0
Materials					
Temporary materials	2,000.00	$/wk	4.50	1.00	9,000
Thrust frame	5,000.00	$/wk	4.50	1.00	22,500
					$31,500
			Total Estimated Cost:		$737,391

Estimate Definition ID: 2636

Estimated by: ____________________

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Detailed Cost Estimate Report

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Project:	Newfoundland Fixed Link Pre-feasibility Study	**Project Number:**	213789
Estimate Description:	Tunnel drive	**Parent Estimate ID:**	1559
Tunnel Name:	Single Rail Bored	**Project Phase:**	Conceptual
Construction Activity:	TBM Tunneling	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	May 21, 2004
Estimate Definition ID:	2637	**Tunnel Characteristics ID:**	843

Tunnel Characteristics

Tunnel Length:	26,322	m
Finished Diameter:	7.5	m
Initial Support Type:	Pre-cast concrete segments	
Initial Support Thickness:	0	m
Final Lining Thickness:	0.35	m
Grout Thickness:	0.1	m

Theoretical Excavation Volumes

Total Neat Excavation:	1,458,703	Cubic Metres
Initial Lining Volume:	0	Cubic Metres
Final Lining Volume:	227,199	Cubic Metres
Theoretical Grout Volume:	68,635	Cubic Metres

Normal Excavation/Support Cycle

Excavation Cycle Length:	1.5	Metres
Excavate:	24	Minutes
Erect Support:	27	Minutes
Extend Services:	0	Minutes
Total Cycle Time:	51	Minutes

Difficult Excavation/Support Cycle

Length of Difficult Excavation:	1400	Metres
Excavate:	73	Minutes
Erect Support:	54	Minutes
Extend Services:	0	Minutes
Total Cycle Time:	127	Minutes

Reduction Factors

Machine availability:	80	%
Back up efficiency:	55	%
Planned maintenance:	5	%
Learning curve efficiency:	40	%
Learning curve duration time:	8	Weeks

Learning Curve Rate:	7.1	m/day
Experienced Advance Rate:	17.7	m/day
Difficult Advance Rate:	7.1	m/day

TBM Skidding Through Excavation

Duration of skidding:	0	Weeks
Length of skidding:	0	Metres

Advance Rate and Shift Details

Shift Arrangement:	3 - 8 hour shifts x 7 days per week	
Avg. Drive Advance per Shift:	5.36	Metres
Avg. Drive Advance per Day:	16	Metres
Avg. Drive Advance per Week:	112	Metres
Duration of Tunneling (Incl. Skid):	234.04	Weeks
Total number of shifts (Incl. Skid):	4,915	

	Metres	Days
Learning Curve Drive:	397	56
Experienced Drive:	24,525	1,385
Difficult Drive:	1,400	197
Skidding Portion:	0	0

Estimate Definition ID: 2637

Estimated by: ____________________

Checked by: ____________________

	Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor						
	Pit boss	52.29	$/hr	39,322.00	1.00	2,056,147
	Working foreman	52.29	$/hr	39,322.00	2.00	4,112,295
	Tunnel miner	48.89	$/hr	39,322.00	3.00	5,767,358
	Tunnel laborer	48.44	$/hr	39,322.00	4.00	7,619,031
	Loco driver	49.34	$/hr	39,322.00	5.00	9,700,737
	Shaft bottom	48.44	$/hr	39,322.00	1.00	1,904,758
	TBM operator	49.34	$/hr	39,322.00	1.00	1,940,147
	Tunnel fitter	49.34	$/hr	39,322.00	1.00	1,940,147
	Tunnel electrician	49.34	$/hr	39,322.00	1.00	1,940,147
	Shaft top	47.99	$/hr	39,322.00	2.00	3,774,126
	Crane operator	49.34	$/hr	39,322.00	1.00	1,940,147
	Surface laborer	47.99	$/hr	39,322.00	4.00	7,548,251
	Equipment laborer	48.44	$/hr	39,322.00	4.00	7,619,031
					30.00	$57,862,323
Plant						
	TBM	300,000.00	$/m2	55.42	0.80	13,300,800
	TBM backup	1,430,000.00	$/Nr	1.00	1.00	1,430,000
	Loco	5,000.00	$/wk	234.04	5.00	5,851,000
	Muck cars & grout cars	1,900.00	$/wk	234.04	35.00	15,563,660
	Flat cars	310.00	$/wk	234.04	10.00	725,524
	Manriders	310.00	$/wk	234.04	2.00	145,105
	Track	130.00	$/m	26,322.00	1.00	3,421,860
	Air pipe	30.00	$/m	26,322.00	1.00	789,660
	Water pipe	25.00	$/m	26,322.00	1.00	658,050
	Pump main	50.00	$/m	26,322.00	1.00	1,316,100
	Cabling	80.00	$/m	26,322.00	1.00	2,105,760
	Lighting	30.00	$/m	26,322.00	1.00	789,660
	Vent ducting	30.00	$/m	26,322.00	1.00	789,660
	Grout mixers	7,100.00	$/wk	234.04	1.00	1,661,684
	Grout pumps	3,400.00	$/wk	234.04	1.00	795,736
	Grout hoses & pipes	196.00	$/wk	234.04	2.00	91,744
	Transformers & switchgear - LV	750.00	$/wk	234.04	2.00	351,060
	Small tools	2,600.00	$/wk	234.04	1.00	608,504
	Shaft crane	9,000.00	$/wk	234.04	1.00	2,106,360
	Compressors	950.00	$/wk	234.04	1.00	222,338
	Low pressure C/A system	3,800.00	$/wk	234.04	1.00	889,352
	Pipework and controls	655.00	$/wk	234.04	2.00	306,592
	Generators	2,000.00	$/wk	234.04	1.00	468,080
	Transformers & switchgear - HV	5,200.00	$/wk	234.04	1.00	1,217,008
	Surface fans	800.00	$/wk	234.04	2.00	374,464
	Loaders	2,300.00	$/wk	234.04	2.00	1,076,584
	Other surface plant	2,600.00	$/wk	234.04	1.00	608,504

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Tunnel C/A system	40,000.00	$/wk	234.04	1.00	9,361,600
					$67,026,449
Consumables					
Electrical power	0.10	$/kwh	39,322.00	3,000.00	11,796,600
Gas oil	0.45	$/L	48,000.00	1.00	21,600
Lubrication materials	90.00	$/wk	234.04	1.00	21,064
TBM spares, cutters	250.00	$/m	26,322.00	1.00	6,580,500
Filters etc.	300.00	$/wk	234.04	1.00	70,212
Hydraulic oil	0.90	$/L	32,000.00	1.00	28,800
Other consumables	160.00	$/wk	234.04	1.00	37,446
Tail seal grease	100.00	$/m	26,322.00	1.00	2,632,200
					$21,188,422
Materials					
Concrete lining rings	8,300.31	$/Nr	17,548.00	1.00	145,653,824
Gaskets	130.00	$/m	26,322.00	1.00	3,421,860
Bolts	12.00	$/Nr	1,765.00	30.00	635,400
Grout	145.00	$/m3	68,635.00	1.00	9,952,075
Grout plugs	0.50	$/Nr	1,765.00	7.00	6,178
Packers	10.00	$/Nr	3,633.00	12.00	435,960
Temporary materials	2,250.00	$/wk	234.04	1.00	526,590
Other materials	0.00	$/t	0.00	1.00	0
					$160,631,886
Subcontracts					
Soil disposal	20.00	$/m3	1,458,703.00	1.50	43,761,090
					$43,761,090

Total Estimated Cost:	$350,470,170
Total Estimated Cost per Metre:	$13,315
Total Estimated Cost per Week:	$1,497,491
Total Estimated Cost per Shift:	$71,302

Estimated by: ______________

Checked by: ______________

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Tunnel Estimating Database

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Detailed Cost Estimate Report

Project:	Newfoundland Fixed Link Pre-feasibility Study	**Project Number:**	213789
Estimate Description:	Maintain TBM	**Parent Estimate ID:**	1561
Tunnel Name:	Single Rail Bored	**Project Phase:**	Conceptual
Construction Activity:	TBM Maintenance	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	May 21, 2004
Estimate Definition ID:	2638	**Tunnel Characteristics ID:**	843

Tunnel Characteristics

Finished Diameter: 7.5 m

Activity Details

Shift Arrangement 1 - 6 hour shifts x 1 days per week

Duration of Activity 234 Weeks

Total Number of Shifts 234

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor					
Working foreman	52.29	$/hr	1,404.00	1.50	110,123
Loco driver	49.34	$/hr	1,404.00	1.50	103,910
Shaft bottom	48.44	$/hr	1,404.00	1.50	102,015
TBM operator	49.34	$/hr	1,404.00	1.50	103,910
Tunnel fitter	49.34	$/hr	1,404.00	1.50	103,910
Tunnel electrician	49.34	$/hr	1,404.00	1.50	103,910
Shaft top	47.99	$/hr	1,404.00	1.50	101,067
Surface laborer	47.99	$/hr	1,404.00	1.50	101,067
				12.00	$829,911
Consumables					
Electrical power	0.10	$/kwh	1,404.00	600.00	84,240
Gas oil	0.45	$/L	0.00	1.00	0
Other consumables	0.00	$/wk	234.00	1.00	0
					$84,240
Materials					
Temporary materials	200.00	$/wk	234.00	1.00	46,800
Other materials	0.00	$/t	0.00	1.00	0
					$46,800
			Total Estimated Cost:		$960,951

Estimate Definition ID: 2638

Estimated by: ____________

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Detailed Cost Estimate Report

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Project:	Newfoundland Fixed Link Pre-feasibility Study	**Project Number:**	213789
Estimate Description:	Clean tunnel	**Parent Estimate ID:**	1562
Tunnel Name:	Single Rail Bored	**Project Phase:**	Conceptual
Construction Activity:	Tunnel Clean Up	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	May 21, 2004
Estimate Definition ID:	2639	**Tunnel Characteristics ID:**	843

Tunnel Characteristics

Tunnel Length:	26,322	m	
Finished Diameter:	7.5	m	(Circular Tunnels)
Excavated Cross Section:	0	m2	(Non-circular Tunnels)
Excavated Perimeter:	0	m	(Non-circular Tunnels)

Productivity Cycle

Section Length	30	Metres
Vent Line Removal Time	120	Minutes
Track Removal Time	60	Minutes
Temp Lighting Removal Time	60	Minutes
Clean Up Time	120	Minutes
Total Cycle Time	360	Minutes

Reduction Factors

Learning Curve Efficiency:	50	%
Back Up Efficiency:	80	%
Learning Curve Duration:	1	Weeks

Shift Details

Shift Arrangement: 3 - 8 hour shifts x 7 days per week
Avg. Advance per Shift: 31.58 Metres
Avg. Advance per Week: 664 Metres
Total number of hours: 6,669

Clean Up Productivity Data

	Average Advance		Drive Length		Drive Duration					
Learning Curve Portion:	48.0	m/day	336	Metres	21	Shifts	7	Days	1.00	Weeks
Experienced Drive Portion:	96.0	m/day	25,986	Metres	812	Shifts	271	Days	38.67	Weeks
Total:	94.8	m/day	26,322	Metres	834	Shifts	278	Days	39.67	Weeks

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor					
Tunnel laborer	48.44	$/hr	6,668.00	6.00	1,937,988
Shaft bottom	48.44	$/hr	6,668.00	1.00	322,998
Shaft top	47.99	$/hr	6,668.00	1.00	319,997
Crane operator	49.34	$/hr	6,668.00	1.00	328,999
				9.00	$2,909,982
Plant					
Transformers & switchgear - LV	750.00	$/wk	39.67	1.00	29,753

Estimated by: ____________

Checked by: ____________

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Man hoists	2,600.00	$/wk	39.67	1.00	103,142
Shaft crane	9,000.00	$/wk	39.67	1.00	357,030
Compressors	950.00	$/wk	39.67	1.00	37,687
Loaders	2,260.00	$/wk	39.67	1.00	89,654
Other surface plant	2,600.00	$/wk	39.67	1.00	103,142
Bobcat	500.00	$/wk	39.67	1.00	19,835
					$740,242

Consumables

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Electrical power	0.10	$/kwh	6,668.00	200.00	133,360
					$133,360

Total Estimated Cost:	$3,783,584
Total Estimated Cost per Metre:	$144
Total Estimated Cost per Week:	$95,377
Total Estimated Cost per Shift:	$4,539

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Detailed Cost Estimate Report

Project:	Newfoundland Fixed Link Pre-feasibility Study	**Project Number:**	213789
Estimate Description:	Remove TBM	**Parent Estimate ID:**	1564
Tunnel Name:	Single Rail Bored	**Project Phase:**	Conceptual
Construction Activity:	TBM Removal	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	May 21, 2004
Estimate Definition ID:	2640	**Tunnel Characteristics ID:**	843

Tunnel Characteristics

Finished Diameter: 7.5 m

Activity Details

Shift Arrangement 3 - 8 hour shifts x 7 days per week

Duration of Activity 2.2 Weeks

Total Number of Shifts 46.2

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor					
Pit boss	52.29	$/hr	370.00	1.00	19,347
Tunnel miner	48.89	$/hr	370.00	3.00	54,268
Shaft bottom	48.44	$/hr	370.00	2.00	35,846
Tunnel fitter	49.34	$/hr	370.00	1.00	18,256
Tunnel electrician	49.34	$/hr	370.00	1.00	18,256
Shaft top	47.99	$/hr	370.00	2.00	35,513
Crane operator	49.34	$/hr	370.00	2.00	36,512
Surface laborer	47.99	$/hr	370.00	2.00	35,513
Equipment laborer	48.44	$/hr	370.00	1.00	17,923
				15.00	$271,432
Plant					
Loco	5,000.00	$/wk	2.20	1.00	11,000
Muck cars & grout cars	1,900.00	$/wk	2.20	6.00	25,080
Flat cars	310.00	$/wk	2.20	4.00	2,728
Manriders	310.00	$/wk	2.20	1.00	682
Booster fans	800.00	$/wk	2.20	1.00	1,760
Transformers & switchgear - LV	750.00	$/wk	2.20	1.00	1,650
Other plant	1,400.00	$/wk	2.20	1.00	3,080
Man hoists	2,000.00	$/wk	2.20	1.00	4,400
Shaft crane	9,000.00	$/wk	2.20	1.00	19,800
50T Crane	3,000.00	$/wk	2.20	1.00	6,600
TBM Crane	15,000.00	$/wk	2.20	1.00	33,000
Compressors	950.00	$/wk	2.20	1.00	2,090
Transformers & switchgear - HV	5,200.00	$/wk	2.20	1.00	11,440
Surface fans	800.00	$/wk	2.20	1.00	1,760
					$125,070

Estimate Definition ID: 2640 **Estimated by:** ____________________

Checked by: ____________________

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Consumables					
Electrical power	0.00	$/kwh	370.00	600.00	0
Gas oil	0.40	$/L	15.00	1,000.00	6,000
Lubrication materials	0.00	$/wk	2.20	1.00	0
Filters etc.	0.00	$/wk	2.20	1.00	0
Hydraulic oil	0.00	$/L	0.00	1.00	0
Other consumables	500.00	$/wk	2.20	1.00	1,100
					$7,100
Materials					
Temporary materials	500.00	$/wk	2.20	1.00	1,100
Thrust frame	0.00	$/wk	2.20	1.00	0
					$1,100
General Supplies					
Small tools	700.00	$/wk	2.20	1.00	1,540
					$1,540
			Total Estimated Cost:		$406,242

Estimate Definition ID: 2640

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Detailed Cost Estimate Report

Project:	NFLink	**Project Number:**	213789
Estimate Description:	Liner production	**Parent Estimate ID:**	1596
Tunnel Name:	Single Rail Bored	**Project Phase:**	Conceptual
Construction Activity:	Precast Linings	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	June 01, 2004
Estimate Definition ID:	2642	**Tunnel Characteristics ID:**	843

Tunnel Characteristics

Tunnel Length:	26,322	m
Finished Diameter:	7.5	m
Final Lining Thickness:	0.35	m

Assumptions

A) Duration

	Maximum	Minimum	
TBM Fabrication Time	19	15	Months
TBM Erection Time	3	2	Months
Tunneling Time	86	81	Months
Total	**108**	**98**	Months
Facility Setup Time	6	5	Months
Learning Curve/Shakedown Time	1	1	Months
Concrete Strength Gain Time	1	1	Months
Available Manufacturing Time	**100**	**91**	Months

B) Production

Allowance for Damage	2	%
Ring Length	1.5	m
Number of Rings Required	17,899	
Production Rate Required	49.2	Rings/Week
Actual Production Rate Achieved	50	Rings/Week

Investment on plant, equipment and moulds $5,000,000

Initial Shakedown Time	4	Weeks
Production Time	358.0	Weeks

	Shakedown Crew	Production / QC Crew
Shifts per Day	1	2
Hours per Shift	12	12
Days per Week	5	5

Estimate Definition ID: 2642

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Checked by: ____________

Number of Rings per Truck	1	
Concrete	12.95	m3/ring
Reinforcing Steel	120	kg/m3
Dunnage Assumption	50	% of total required storage

C) Overheads

	$/Month	Months	Cost	
Project Manager Rate	7,000	97	679,000	
Plant Manager Rate	5,000	95	475,000	
Quality Manager Rate	5,000	93	465,000	
Secretary Rate	2,000	97	194,000	
Office Building Cost			150,000	
Office Equipment and Supplies Cost			0	
Finance Assume $	1,000,000	97	485,000	
Financing @	6 %			
Head Office Support @	1 %		1,286,778	
Total Overhead Cost				$3,734,778
Profit Margin			10 %	

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor					
Shakedown crew	25.00	$/hr	240.00	30.00	180,000
Production & QC crew	32.00	$/hr	42,958.00	30.00	41,239,680
				60.00	$41,419,680
Consumables					
Power	0.06	$/kwh	43,198.00	1,020.00	2,643,718
Heating	0.11	$/m2/wk	362.00	10,600.00	422,092
Steam curing	0.54	$/m2/wk	362.00	2,000.00	390,960
Fuel	0.50	$/L	362.00	3,000.00	543,000
Water	0.05	$/L	231,743.00	100.00	1,158,715
					$5,158,485
Materials					
Concrete	84.00	$/m3	12.95	17,899.00	19,470,532
Rebar	1.00	$/kg	1,554.00	17,899.00	27,815,046
Grout nozzles	3.00	$/Nr	17,899.00	12.00	644,364
Lifting socket	10.00	$/Nr	17,899.00	12.00	2,147,880
Bolt inserts	5.00	$/Nr	17,899.00	12.00	1,073,940
Gaskets	100.00	$/Nr	17,899.00	12.00	21,478,800
Dunnage	2.50	$/m	18.00	8,949.00	402,705
Site preparation	10.00	$/m2	12.32	8,949.00	1,102,517
					$74,135,784

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Subcontracts					
Delivery	80.00	$/hr	2.00	17,899.00	2,863,840
Testing	100,000.00	$/Nr	1.00	1.00	100,000
					$2,963,840

Subtotal: $123,677,789

Investment on Plant: $5,000,000

Total Overhead Cost: $3,734,778

Subtotal: $132,412,566

Profit: $13,241,257

Total Precast Lining Cost: **$145,653,823**

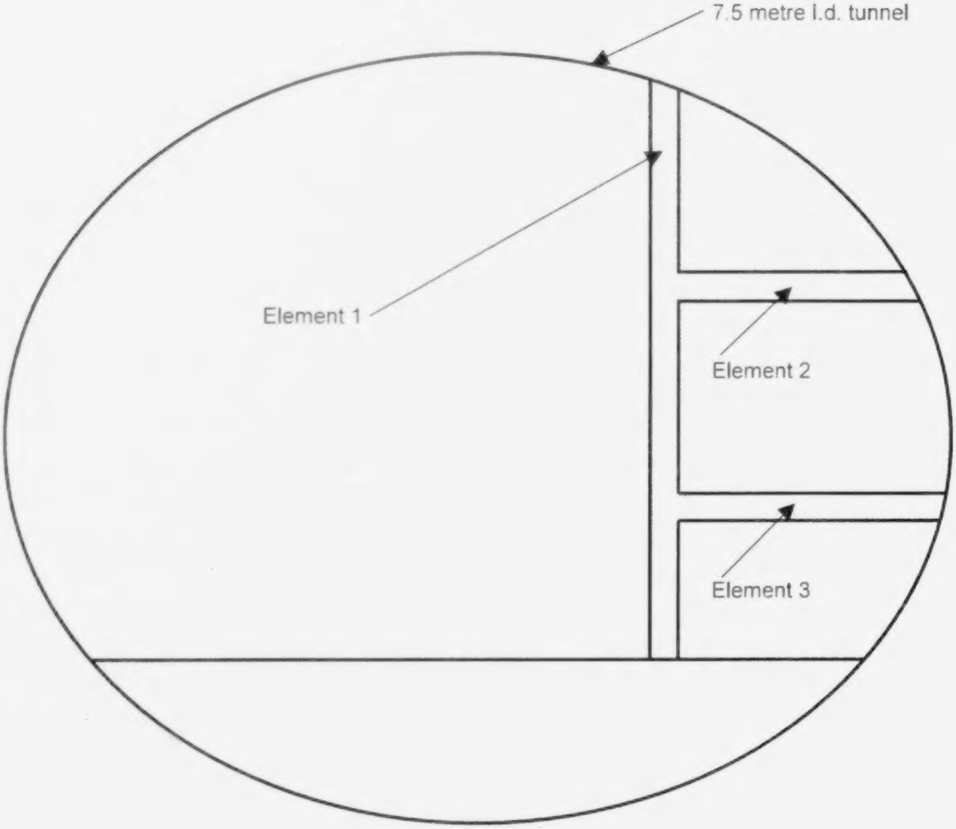
Total Cost per Cubic Metre: **$629**

Total Cost per Ring: **$8,138**

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Bored Railway Tunnel
Tunnel Structural Finishes

Page 1 of 2
Date: June 07, 2004
Calculation by: A.White

Tunnel length= 26320 m


7.5 metre I.d. tunnel
Element 1
Element 2
Element 3

Assumed tunnel cross section

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Bored Railway Tunnel
Tunnel Structural Finishes

Date: June 07, 2004
Calculation by: A.White

Quantity Take-off

Concrete

Element	Nr.	L(m)	b(m)	d(m)	Concrete Qty(m3)		Rebar Qty(m3)	
1	1	26320	0.3	5.9	46586		5590.4	
2	1	26320	1.2	0.3	9475.2		1137.0	
3	1	26320	1.2	0.3	9475.2		1137.0	
					65537	m3	6727	t

Formwork/falsework

Element	Nr.	L(m)	d(m)	Faces	Area(m2)	
1	1	26320	5.9	2	310576	
2	1	26320	1.2	1	31584	
3	1	26320	1.2	1	31584	
					373744	m2

Rates

Concrete	m3	190
Formwork	m2	140
Reinforcement	t	1600

Costs

Concrete	m3	65537	m3	at	190	=	12,451,992
Formwork	m2	373744	m2	at	140	=	52,324,160
Reinforcement	t	6727	t	at	1600	=	10,763,827
						$	75,539,979

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: North Approach
Option: Bored Rail Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient	-0.08	%	+ sloping same way as track/road - sloping against track/road
Track/Road Gradient	1.663	%	
Ground elevation at portal	100	m	
Bottom of slab elevation at portal	86.95	m	
Total length=	748.7091	m	
Total Cost=$	7.8	M	

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Bored Railway Tunnel
Tunnel Structural Finishes

Page 2 of 2
Date: June 07, 2004
Calculation by: A.White

Quantity Take-off

Concrete

Element	Nr.	L(m)	b(m)	d(m)	Concrete Qty(m3)	Rebar Qty(m3)
1	1	26320	0.3	5.9	46586	5590.4
2	1	26320	1.2	0.3	9475.2	1137.0
3	1	26320	1.2	0.3	9475.2	1137.0
					65537 m3	6727 t

Formwork/falsework

Element	Nr.	L(m)	d(m)	Faces	Area(m2)
1	1	26320	5.9	2	310576
2	1	26320	1.2	1	31584
3	1	26320	1.2	1	31584
					373744 m2

Rates

Concrete	m3	190
Formwork	m2	140
Reinforcement	t	1600

Costs

Concrete	m3	65537	m3	at	190	=	12,451,992
Formwork	m2	373744	m2	at	140	=	52,324,160
Reinforcement	t	6727	t	at	1600	=	10,763,827
						$	75,539,979

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: North Approach
Option: Bored Rail Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient	-0.08	%	+ sloping same way as track/road - sloping against track/road
Track/Road Gradient	1.663	%	
Ground elevation at portal	100	m	
Bottom of slab elevation at portal	86.95	m	
Total length=	748.7091	m	
Total Cost=$	7.8	M	

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: North Approach
Option: Bored Rail Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient	-2.2	%	+ sloping same way as track/road - sloping against track/road
Track/Road Gradient	1.64	%	
Ground elevation at portal	100	m	
Bottom of slab elevation at portal	86.95	m	
Total length=	339.8438	m	
Total Cost=$	3.5	M	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel

UNIT RATES

Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: North Approach
Option: Bored Rail Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient -2.2 %
Track/Road Gradient 1.64 %

+ sloping same way as track/road
- sloping against track/road

Ground elevation at portal 100 m

Bottom of slab elevation at portal 86.95 m

Total length= 339.8438 m

Total Cost=$ 3.5 M

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel

UNIT RATES

Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel

UNIT RATES

Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel

UNIT RATES

Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

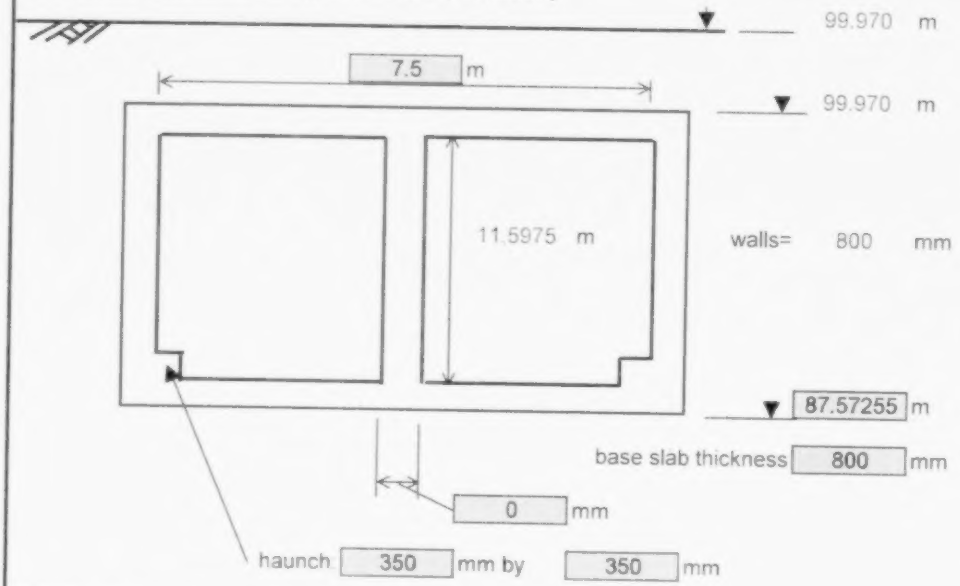
Newfoundland Fixed Link Pre-feasibility Study
North Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 74.87091 m

Section 1

Input cross-section details (cut and cover solution)



99.970 m
7.5 m
99.970 m
11.5975 m
walls= 800 mm
87.57255 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

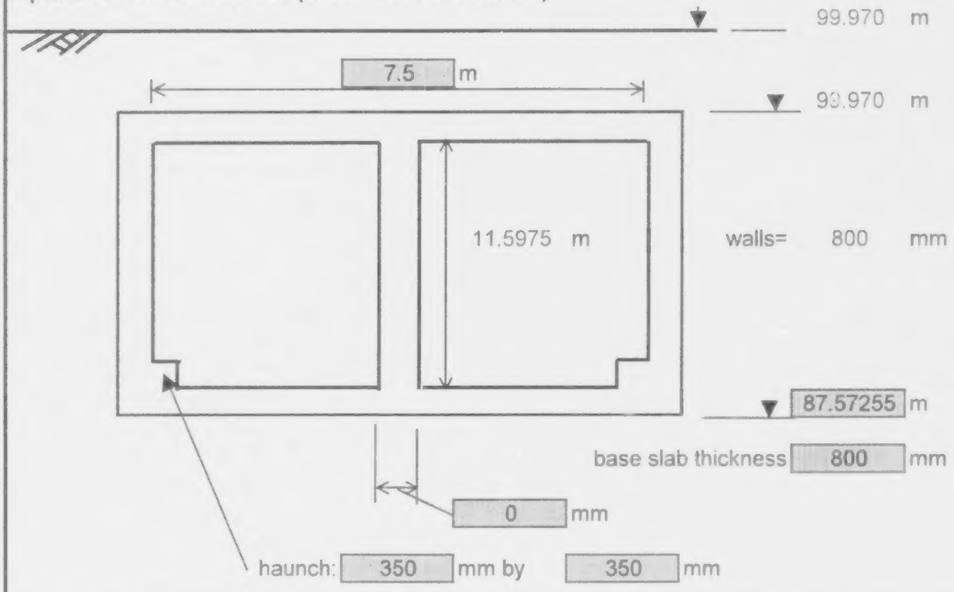
Calculated Quantities

excavation=	8446.7	m3	
concrete=	1952.708	m3	
rebar=	234.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1736.631	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1856.4	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	681.3253	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 74.87091 m **Section** **1**

Input cross-section details (cut and cover solution)



walls= 800 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	8446.7	m3	
concrete=	1952.708	m3	
rebar=	234.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1736.631	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1856.4	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	681.3253	m2	

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
North Approach	**Calculations by:** ANW
Bored Rail Tunnel	**Page 2 of 2**

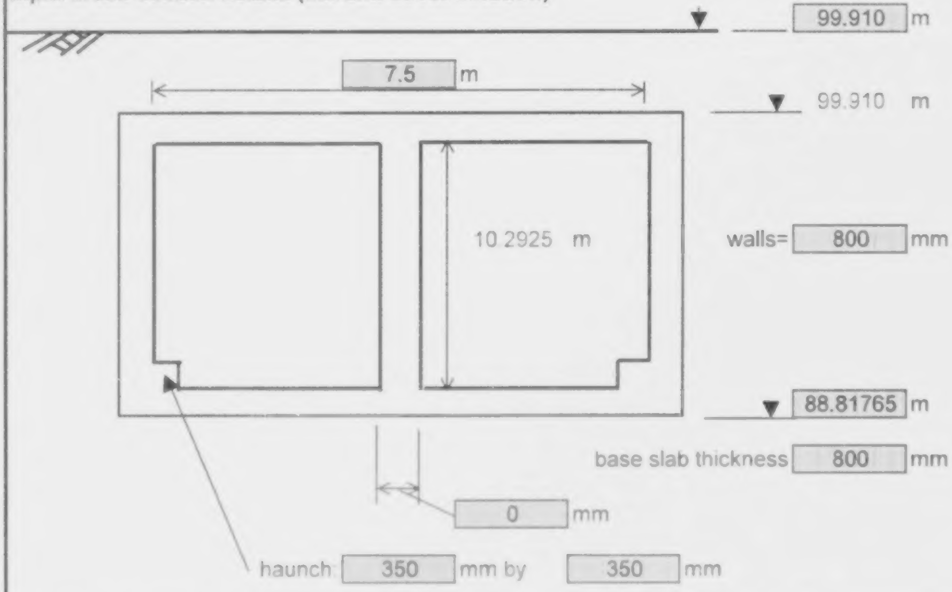
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	8446.7	60	506803.8
concrete	m3	1952.708	190.0	371014.6
rebar	tonnes	234.3	1600	374920
formwork/falsework	m2	1736.631	140	243128.3
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	1856.4	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	681.3253	30	20439.76
			Total	1516306

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 74.87091 m **Section** 2

Input cross-section details (cut and cover solution)



99.910 m
7.5 m
99.910 m
10.2925 m
walls= 800 mm
88.81765 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	7557.6	m3
concrete=	1796.378	m3
rebar=	215.6	tonnes (assume 0.12t/m3 of concrete)
formwork/falsework=	1541.218	m2
SP&L<=4.6m deep	0.0	m2
4.6<SP&L<=6.7m deep	0.0	m2
6.7<SP&L<=10.6m deep	0.0	m2
10.6<SP&L<=13.7m deep	1661.0	m2
13.7<SP&L<=16.8m deep	0.0	m2
16.8<SP&L<=20.0m deep	0.0	m2
20<SP&L<=25m deep	0.0	m2
backfill=	0	m3
surface reinstatement=	681.3253	m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

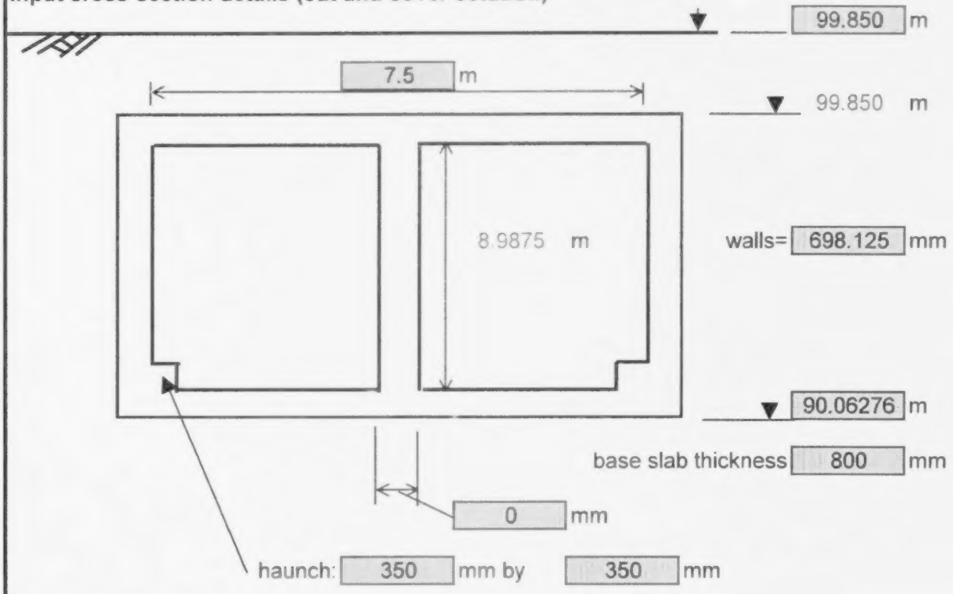
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	7557.6	60	453456.1
concrete	m3	1796.378	190.0	341311.8
rebar	tonnes	215.6	1600	344904.5
formwork/falsework	m2	1541.218	140	215770.5
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	1661.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	681.3253	30	20439.76
			Total	1375883

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 74.87091 m **Section** 3

Input cross-section details (cut and cover solution)


99.850 m
7.5 m
99.850 m
8.9875 m
walls= 698.125 mm
90.06276 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	6519.2	m3	
concrete=	1490.74	m3	
rebar=	178.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1345.805	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1465.6	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	666.0704	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

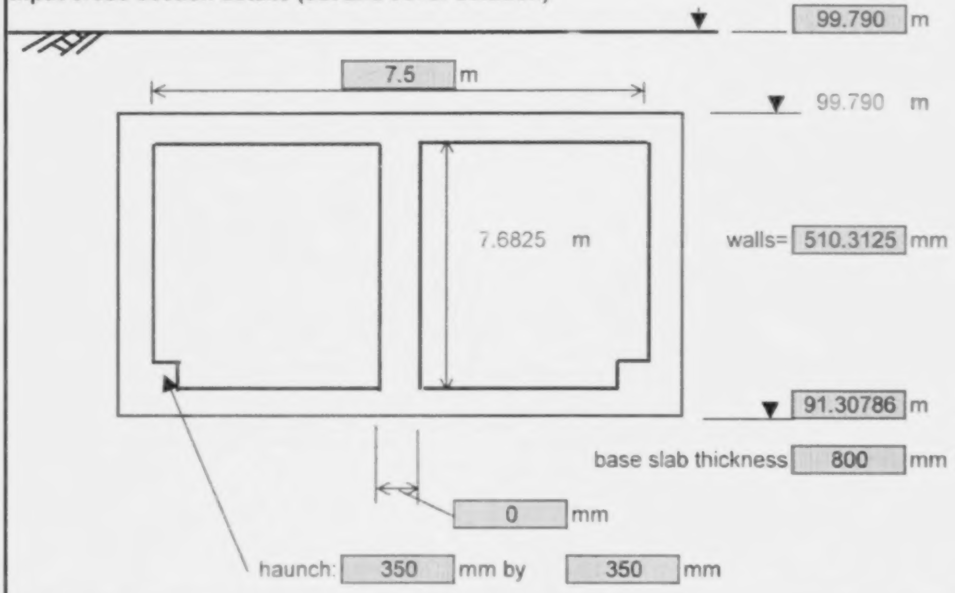
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	6519.2	60	391149.8
concrete	m3	1490.74	190.0	283240.5
rebar	tonnes	178.9	1600	286222
formwork/falsework	m2	1345.805	140	188412.7
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1465.6	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	666.0704	30	19982.11
			Total	1169007

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 74.87091 m **Section 4**

Input cross-section details (cut and cover solution)


99.790 m
7.5 m
99.790 m
7.6825 m
walls= 510.3125 mm
91.30786 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	5411.4	m3	
concrete=	1115.76	m3	
rebar=	133.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1150.392	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1270.2	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	637.947	m2	

Newfoundland Fixed Link Pre-feasibility Study
North Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 2 of 2

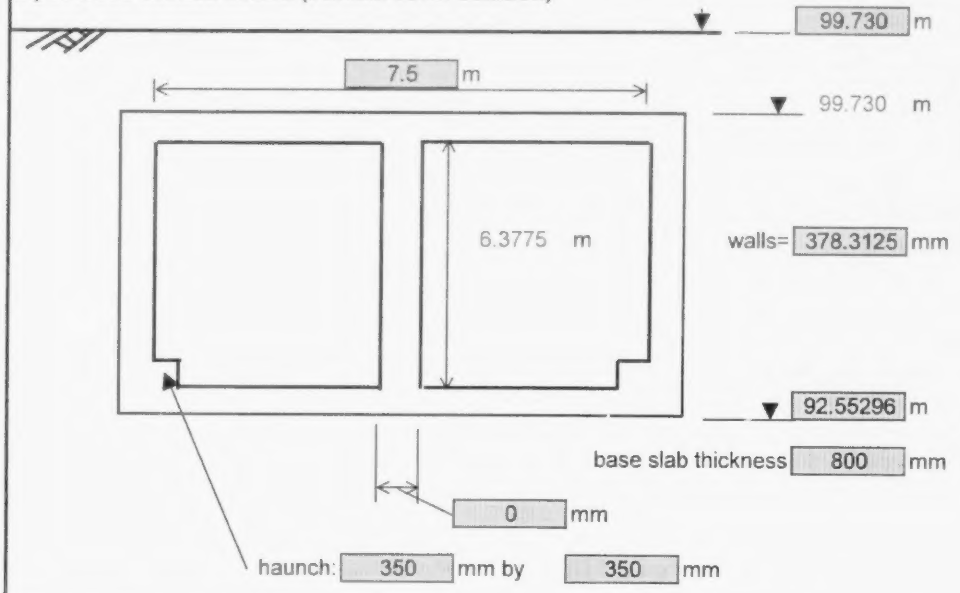
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	5411.4	60	324683.1
concrete	m3	1115.76	190.0	211994.4
rebar	tonnes	133.9	1600	214225.9
formwork/falsework	m2	1150.392	140	161054.8
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1270.2	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	637.947	30	19138.41
			Total	931096.7

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 74.87091 m **Section** **5**

Input cross-section details (cut and cover solution)


99.730 m
7.5 m
99.730 m
6.3775 m
walls= 378.3125 mm
92.55296 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	4437.0	m3
concrete=	874.1685	m3
rebar=	104.9	tonnes (assume 0.12t/m3 of concrete)
formwork/falsework=	954.9785	m2
SP&L<=4.6m deep	0.0	m2
4.6<SP&L<=6.7m deep	0.0	m2
6.7<SP&L<=10.6m deep	1074.8	m2
10.6<SP&L<=13.7m deep	0.0	m2
13.7<SP&L<=16.8m deep	0.0	m2
16.8<SP&L<=20.0m deep	0.0	m2
20<SP&L<=25m deep	0.0	m2
backfill=	0	m3
surface reinstatement=	618.181	m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

Calculated costs

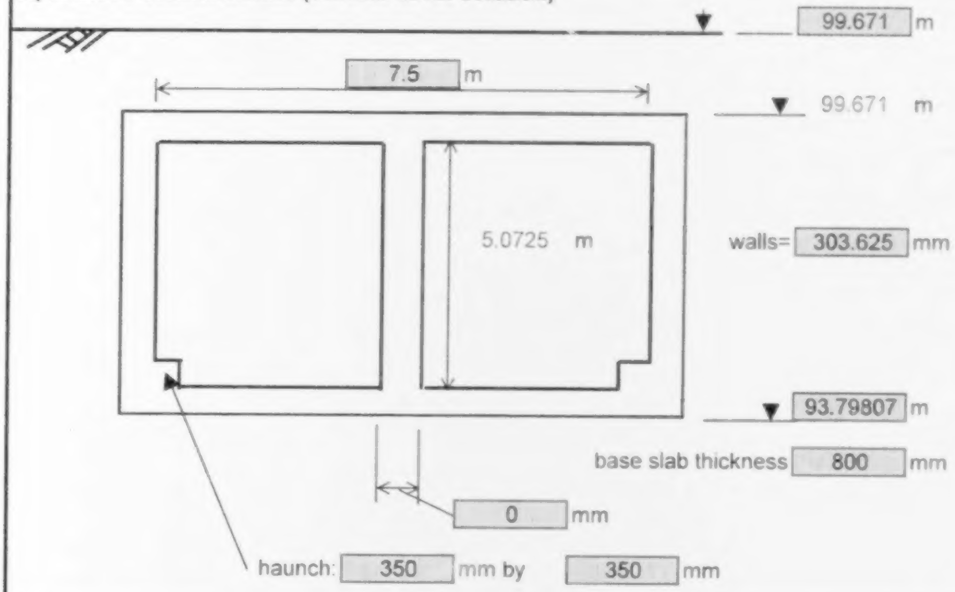
Item	Unit	Quantity	Rate	Cost
excavation	m3	4437.0	60	266219.7
concrete	m3	874.1685	190.0	166092
rebar	tonnes	104.9	1600	167840.4
formwork/falsework	m2	954.9785	140	133697
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1074.8	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	618.181	30	18545.43
			Total	752394.5

Newfoundland Fixed Link Pre-feasibility Study
North Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 74.87091 m
Section 6

Input cross-section details (cut and cover solution)


99.671 m
7.5 m
99.671 m
5.0725 m
walls= 303.625 mm
93.79807 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	3564.6	m3	
concrete=	734.5642	m3	
rebar=	88.1	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	759.5654	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	879.4	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	606.9972	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	3564.6	60	213875.5
concrete	m3	734.5642	190.0	139567.2
rebar	tonnes	88.1	1600	141036.3
formwork/falsework	m2	759.5654	140	106339.2
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	879.4	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	606.9972	30	18209.92
			Total	619028.1

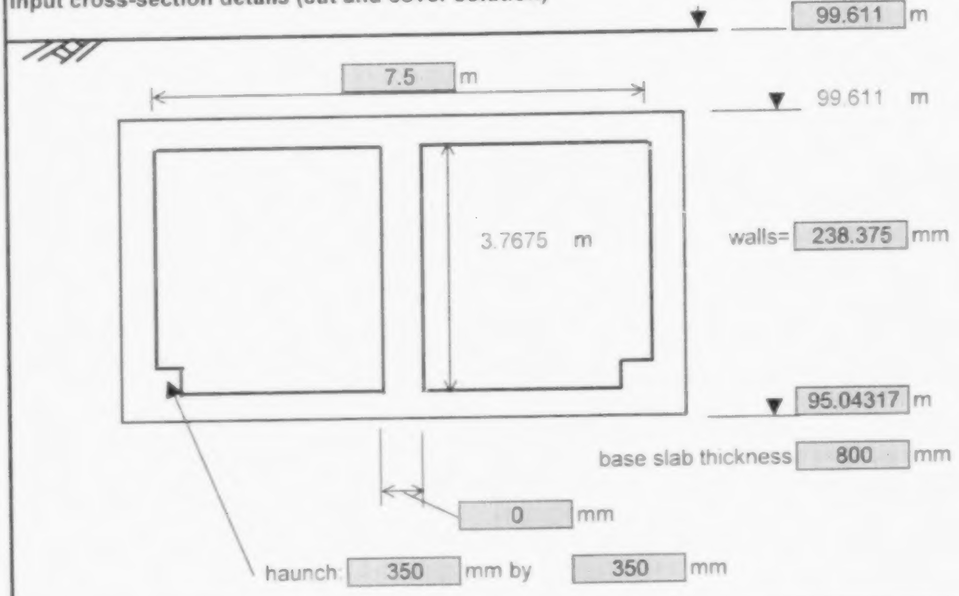
Newfoundland Fixed Link Pre-feasibility Study
North Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 74.87091 m

Section 7

Input cross-section details (cut and cover solution)


99.611 m
7.5 m
99.611 m
3.7675 m
walls= 238.375 mm
95.04317 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	2727.8	m3	
concrete=	630.6044	m3	
rebar=	75.7	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	564.1523	m2	
SP&L<=4.6m deep	683.9	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	597.2265	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

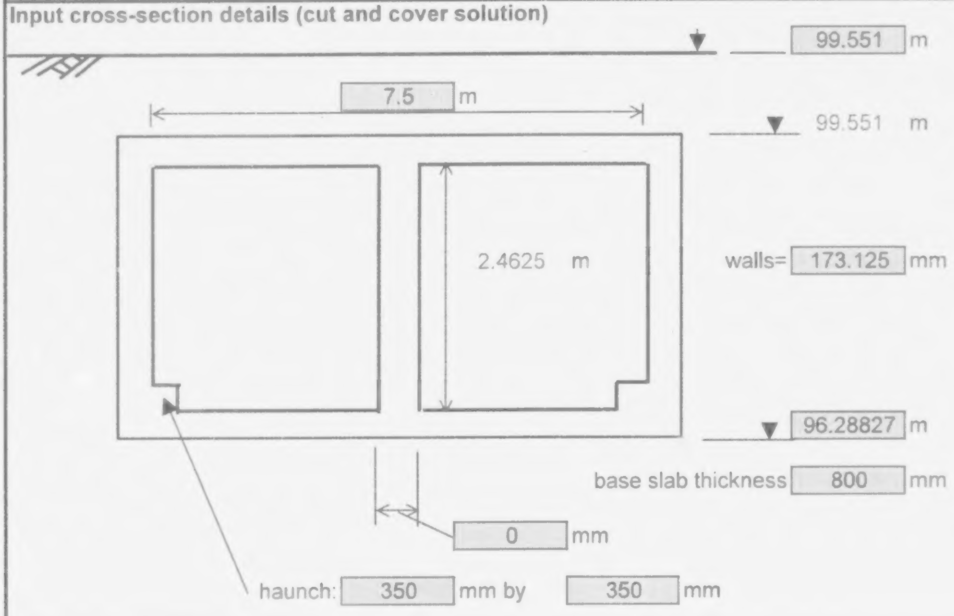
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	2727.8	60	163669.9
concrete	m3	630.6044	190.0	119814.8
rebar	tonnes	75.7	1600	121076
formwork/falsework	m2	564.1523	140	78981.33
SP&L<=4.6m deep	m2	683.9	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	[illegible]	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	597.2265	30	17916.8
			Total	501458.9

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 74.87091 m **Section** **8**

Input cross-section details (cut and cover solution)



walls= 173.125 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	1916.6	m3	
concrete=	552.1461	m3	
rebar=	66.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	368.7392	m2	
SP&L<=4.6m deep	488.5	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	587.4559	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

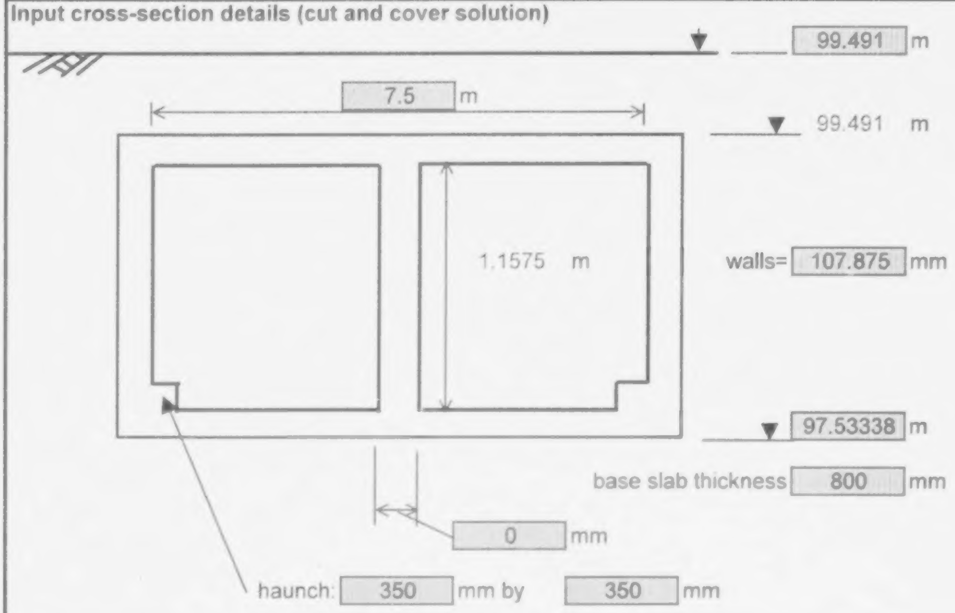
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	1916.6	60	114994.5
concrete	m3	552.1461	190.0	104907.8
rebar	tonnes	66.3	1600	106012
formwork/falsework	m2	368.7392	140	51623.49
SP&L<=4.6m deep	m2	488.5	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	587.4559	30	17623.68
			Total	395161.5

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 74.87091 m **Section** 9

Input cross-section details (cut and cover solution)


99.491 m
7.5 m
99.491 m
1.1575 m
walls= 107.875 mm
97.53338 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	1130.8	m3	
concrete=	499.1891	m3	
rebar=	59.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	173.3262	m2	
SP&L<=4.6m deep	293.1	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	577.6852	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

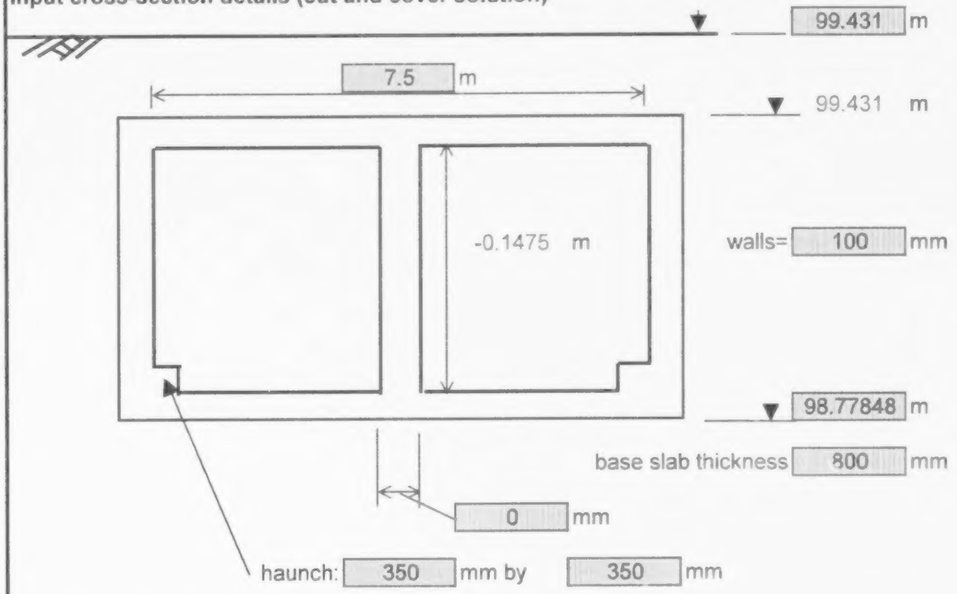
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	1130.8	60	67849.13
concrete	m3	499.1891	190.0	94845.93
rebar	tonnes	59.9	1600	95844.31
formwork/falsework	m2	173.3262	140	24265.66
SP&L<=4.6m deep	m2	293.1	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	577.6852	30	17330.56
			Total	300135.6

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
North Approach	**Calculations by:** ANW
Bored Rail Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 74.87091 m **Section 10**

Input cross-section details (cut and cover solution)


99.431 m
7.5 m
99.431 m
-0.1475 m
walls= 100 mm
98.77848 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	376.2	m3
concrete=	477.3395	m3
rebar=	57.3	tonnes (assume 0.12t/m3 of concrete)
formwork/falsework=	-22.08692	m2
SP&L<=4.6m deep	97.7	m2
4.6<SP&L<=6.7m deep	0.0	m2
6.7<SP&L<=10.6m deep	0.0	m2
10.6<SP&L<=13.7m deep	0.0	m2
13.7<SP&L<=16.8m deep	0.0	m2
16.8<SP&L<=20.0m deep	0.0	m2
20<SP&L<=25m deep	0.0	m2
backfill=	0	m3
surface reinstatement=	576.506	m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	376.2	60	22570.21
concrete	m3	477.3395	190.0	90694.51
rebar	tonnes	57.3	1600	91649.18
formwork/falsework	m2	-22.08692	140	-3092.169
SP&L<=4.6m deep	m2	97.7	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	576.506	30	17295.18
			Total	219116.9

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel

Summary of Costs

Markup for adjacent 0 %

Section	Cost
1	1516306
2	1375883
3	1169007
4	931096.7
5	752394.5
6	619028.1
7	501458.9
8	395161.5
9	300135.6
10	219116.9
Sub-total	7779588

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel

UNIT RATES

Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Highway Tunnel

UNIT RATES

Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: South Approach
Option: Bored Rail Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient	0	%	+ sloping same way as track/road - sloping against track/road
Track/Road Gradient	1.663	%	
Ground elevation at portal	100	m	
Bottom of slab elevation at portal	86.95	m	

Total length= 784.7264 m

Total Cost=$ 8.2 M

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: South Approach
Option: Bored Rail Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient	0	%	+ sloping same way as track/road - sloping against track/road
Track/Road Gradient	1.663	%	
Ground elevation at portal	100	m	
Bottom of slab elevation at portal	86.95	m	
Total length=	784.7264	m	
Total Cost=$	8.2	M	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel

UNIT RATES

Materials

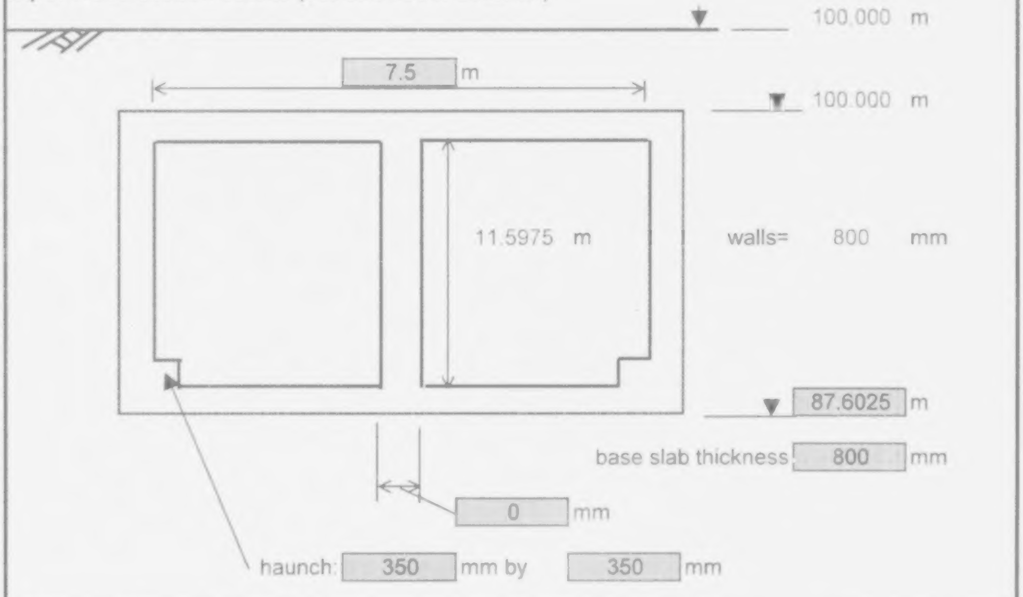
Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 78.47264 m
Section 1

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
11.5975 m
walls= 800 mm
87.6025 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	8853.1	m3	
concrete=	2046.645	m3	
rebar=	245.6	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1820.173	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1945.7	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	714.101	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel

UNIT RATES

Materials

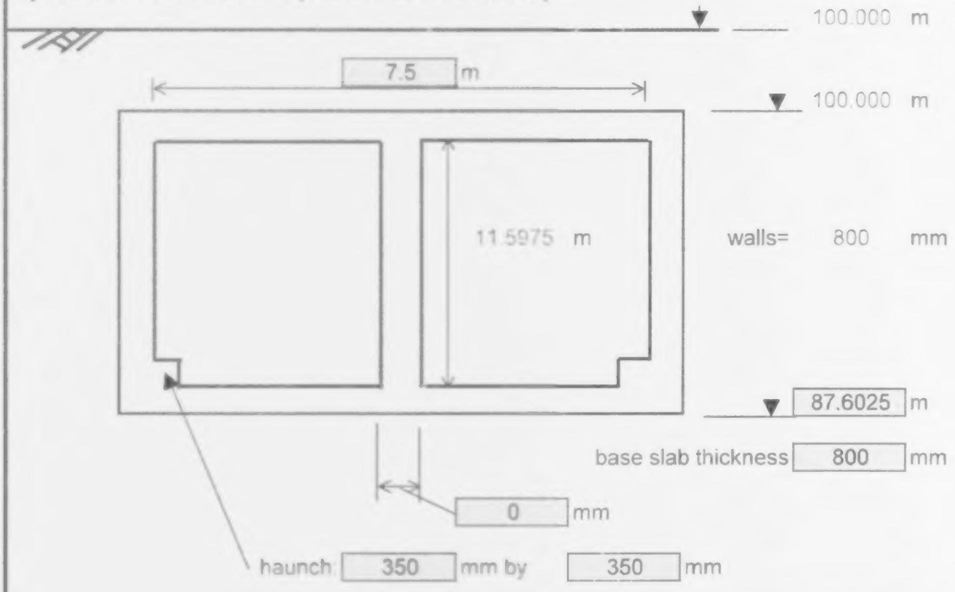
Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 78.47264 m
Section 1

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
11.5975 m
walls= 800 mm
87.6025 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	8853.1	m3	
concrete=	2046.645	m3	
rebar=	245.6	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1820.173	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1945.7	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	714.101	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

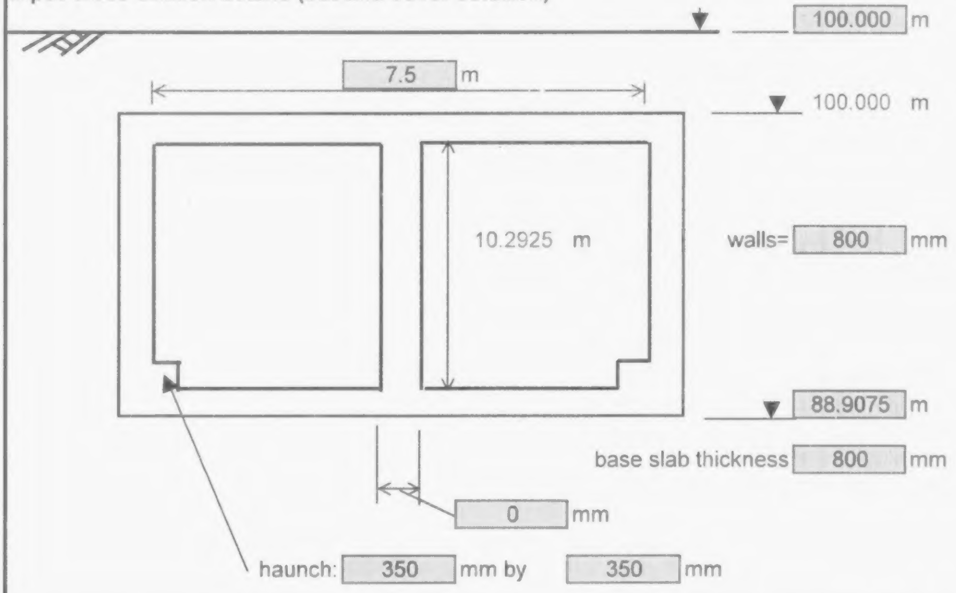
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	8853.1	60	531184
concrete	m3	2046.645	190.0	388862.5
rebar	tonnes	245.6	1600	392955.8
formwork/falsework	m2	1820.173	140	254824.2
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	1945.7	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	714.101	30	21423.03
			Total	1589250

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section** **2**

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
10.2925 m
walls= 800 mm
88.9075 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	7921.2	m3	
concrete=	1882.794	m3	
rebar=	225.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1615.359	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1740.9	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	714.101	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

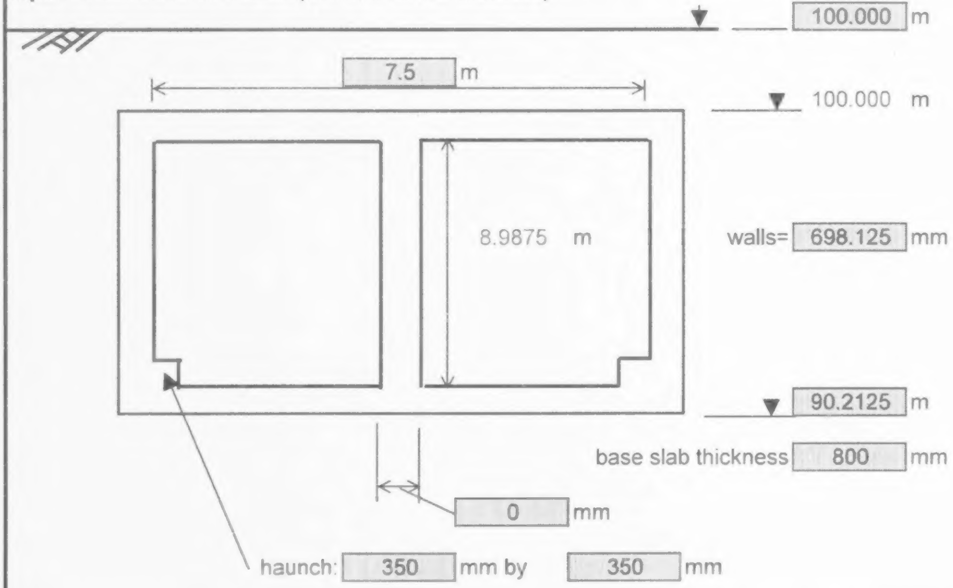
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	7921.2	60	475269.9
concrete	m3	1882.794	190.0	357730.9
rebar	tonnes	225.9	1600	361496.5
formwork/falsework	m2	1615.359	140	226150.3
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	1740.9	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	714.101	30	21423.03
			Total	1442071

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
Bored Rail Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section** **3**

Input cross-section details (cut and cover solution)



walls= 698.125 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	6832.8	m3	
concrete=	1562.453	m3	
rebar=	187.5	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1410.546	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1536.1	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	698.1122	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

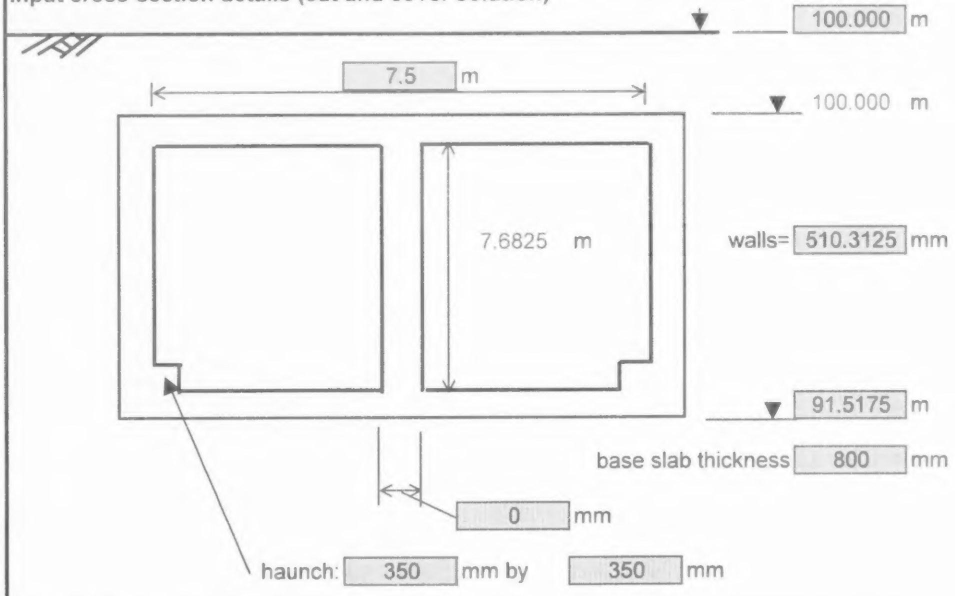
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	6832.8	60	409966.4
concrete	m3	1562.453	190.0	296866
rebar	tonnes	187.5	1600	299990.9
formwork/falsework	m2	1410.546	140	197476.4
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1536.1	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	698.1122	30	20943.37
			Total	1225243

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
Bored Rail Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section** **4**

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
7.6825 m
walls= 510.3125 mm
91.5175 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	5671.7	m3	
concrete=	1169.435	m3	
rebar=	140.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1205.732	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1331.3	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	668.6359	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	5671.7	60	340302.3
concrete	m3	1169.435	190.0	222192.6
rebar	tonnes	140.3	1600	224531.5
formwork/falsework	m2	1205.732	140	168802.5
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1331.3	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	668.6359	30	20059.08
			Total	975887.9

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
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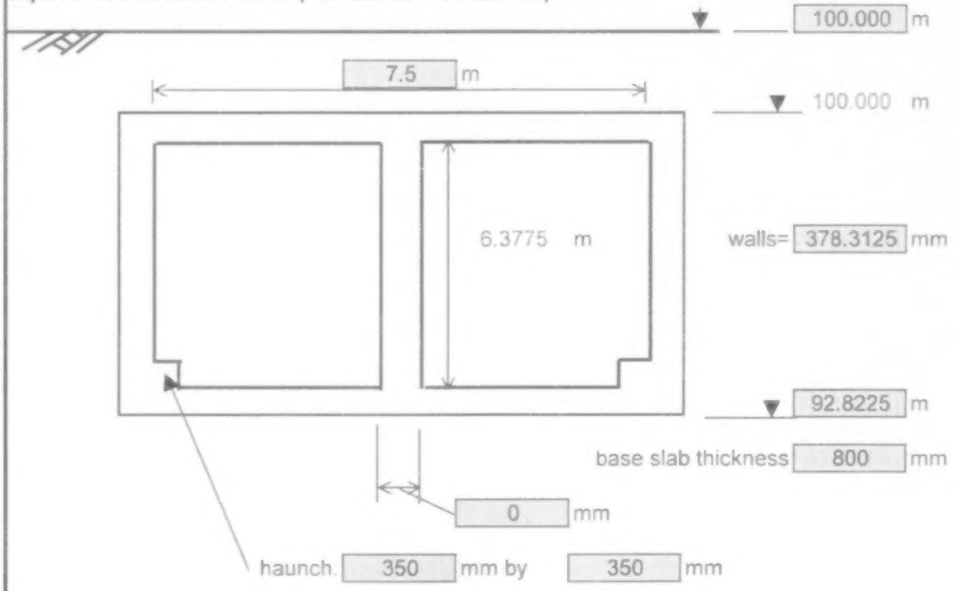
Bored Rail Tunnel	**Page 1 of 2**

Section Cut and Cover

Length of section: 78.47264 m **Section 5**

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
6.3775 m
walls= 378.3125 mm
92.8225 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	4650.4	m3
concrete=	916.2211	m3
rebar=	109.9	tonnes (assume 0.12t/m3 of concrete)
formwork/falsework=	1000.919	m2
SP&L<=4.6m deep	0.0	m2
4.6<SP&L<=6.7m deep	0.0	m2
6.7<SP&L<=10.6m deep	1126.5	m2
10.6<SP&L<=13.7m deep	0.0	m2
13.7<SP&L<=16.8m deep	0.0	m2
16.8<SP&L<=20.0m deep	0.0	m2
20<SP&L<=25m deep	0.0	m2
backfill=	0	m3
surface reinstatement=	647.9192	m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	4650.4	60	279026.4
concrete	m3	916.2211	190.0	174082
rebar	tonnes	109.9	1600	175914.5
formwork/falsework	m2	1000.919	140	140128.6
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1126.5	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	647.9192	30	19437.57
			Total	788589

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
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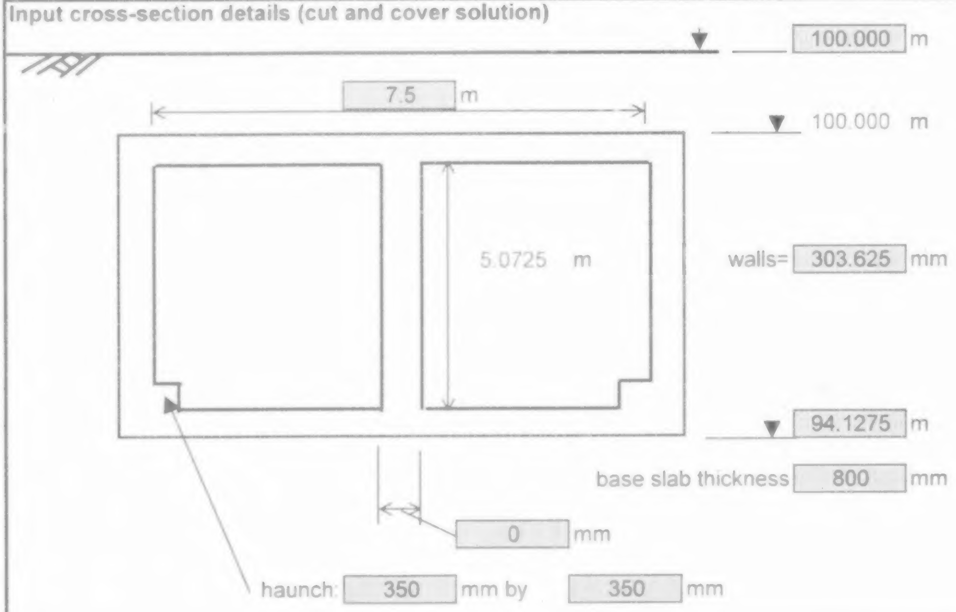
Section Cut and Cover
Length of section: 78.47264 m
Section 6

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
5.0725 m
walls= 303.625 mm
94.1275 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation= 3736.1 m3
concrete= 769.901 m3
rebar= 92.4 tonnes (assume 0.12t/m3 of concrete)
formwork/falsework= 796.1049 m2
SP&L<=4.6m deep 0.0 m2
4.6<SP&L<=6.7m deep 921.7 m2
6.7<SP&L<=10.6m deep 0.0 m2
10.6<SP&L<=13.7m deep 0.0 m2
13.7<SP&L<=16.8m deep 0.0 m2
16.8<SP&L<=20.0m deep 0.0 m2
20<SP&L<=25m deep 0.0 m2
backfill= 0 m3
surface reinstatement= 636.1973 m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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Bored Rail Tunnel **Page 2 of 2**

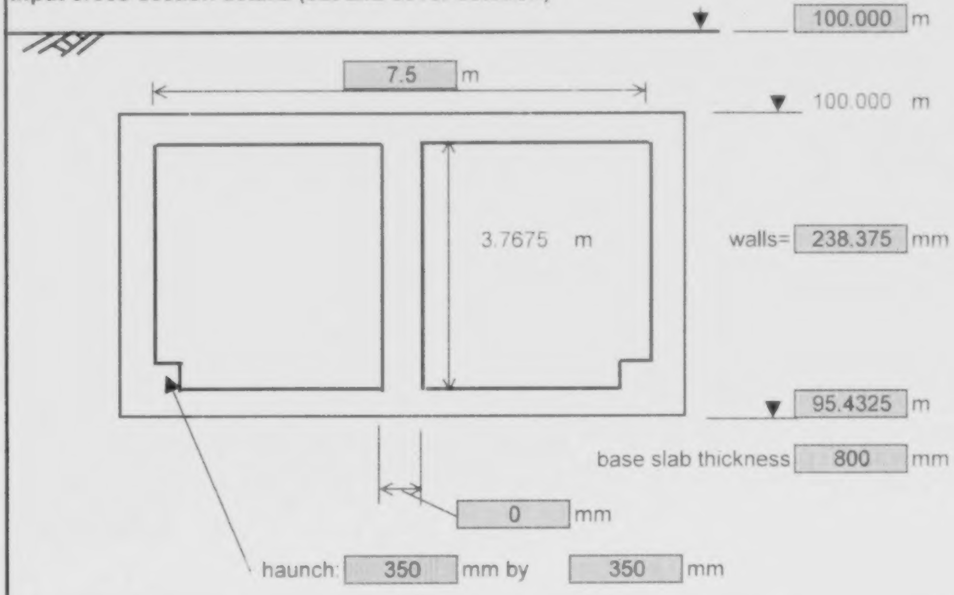
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	3736.1	60	224164.1
concrete	m3	769.901	190.0	146281.2
rebar	tonnes	92.4	1600	147821
formwork/falsework	m2	796.1049	140	111454.7
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	921.7	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	636.1973	30	19085.92
			Total	648806.9

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section** **7**

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
3.7675 m
walls= 238.375 mm
95.4325 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	2859.1	m3	
concrete=	660.9402	m3	
rebar=	79.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	591.2913	m2	
SP&L<=4.6m deep	716.8	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	625.9566	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

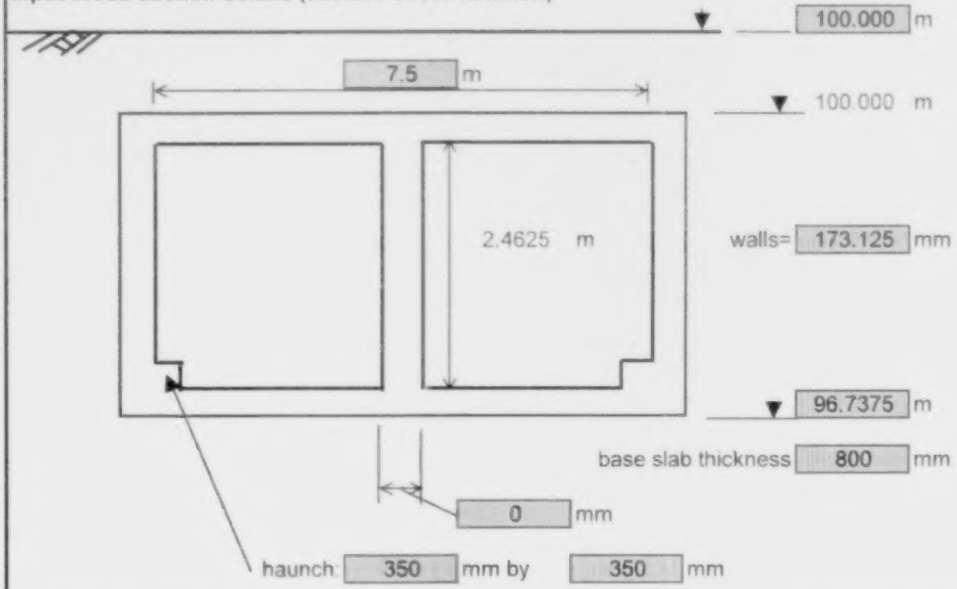
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	2859.1	60	171543.4
concrete	m3	660.9402	190.0	125578.6
rebar	tonnes	79.3	1600	126900.5
formwork/falsework	m2	591.2913	140	82780.79
SP&L<=4.6m deep	m2	716.8	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	625.9566	30	18778.7
			Total	525582

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
Bored Rail Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section** **8**

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
2.4625 m
walls= 173.125 mm
96.7375 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	2008.8	m3
concrete=	578.7075	m3
rebar=	69.4	tonnes (assume 0.12t/m3 of concrete)
formwork/falsework=	386.4778	m2
SP&L<=4.6m deep	512.0	m2
4.6<SP&L<=6.7m deep	0.0	m2
6.7<SP&L<=10.6m deep	0.0	m2
10.6<SP&L<=13.7m deep	0.0	m2
13.7<SP&L<=16.8m deep	0.0	m2
16.8<SP&L<=20.0m deep	0.0	m2
20<SP&L<=25m deep	0.0	m2
backfill=	0	m3
surface reinstatement=	615.716	m2

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	2008.8	60	120526.4
concrete	m3	578.7075	190.0	109954.4
rebar	tonnes	69.4	1600	111111.8
formwork/falsework	m2	386.4778	140	54106.89
SP&L<=4.6m deep	m2	512.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	615.716	30	18471.48
			Total	414171

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Rail Tunnel

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Calculations by: ANW
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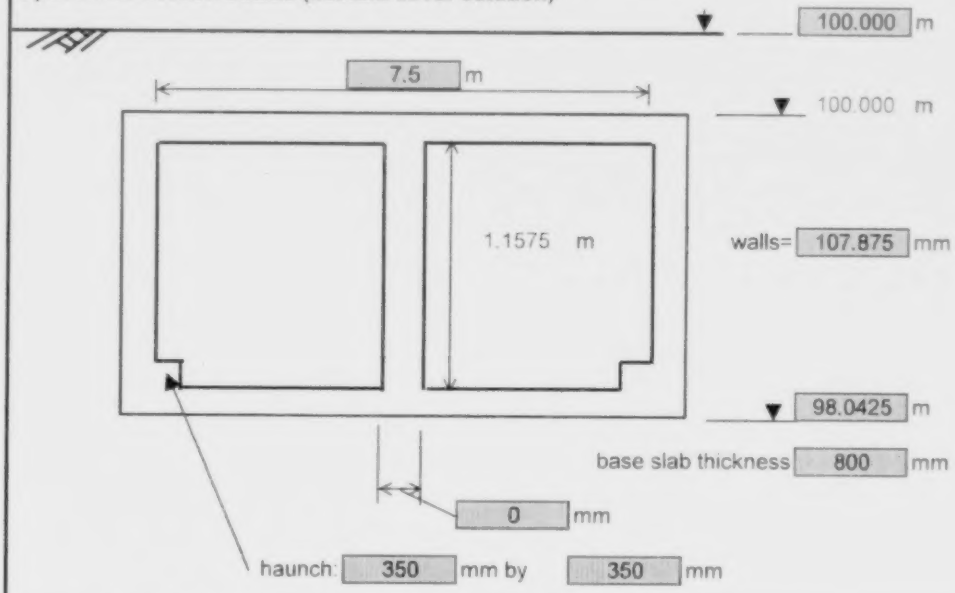
Section Cut and Cover
Length of section: 78.47264 m
Section 9

Input cross-section details (cut and cover solution)



walls= 107.875 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	1185.2	m3	
concrete=	523.203	m3	
rebar=	62.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	181.6642	m2	
SP&L<=4.6m deep	307.2	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	605.4753	m2	

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
Bored Rail Tunnel	**Page 2 of 2**

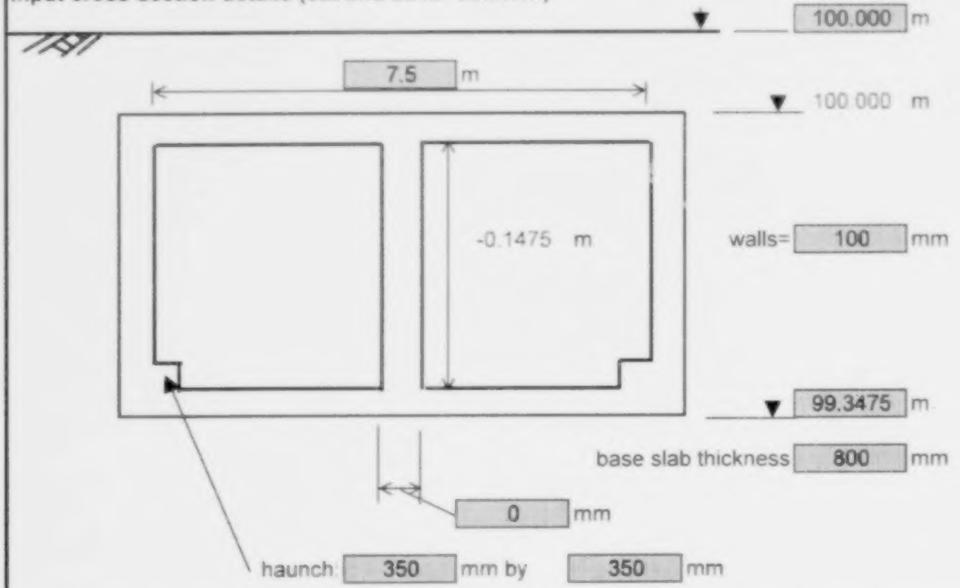
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	1185.2	60	71113.07
concrete	m3	523.203	190.0	99408.58
rebar	tonnes	62.8	1600	100455
formwork/falsework	m2	181.6642	140	25432.98
SP&L<=4.6m deep	m2	307.2	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	605.4753	30	18164.26
			Total	314573.9

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section** **10**

Input cross-section details (cut and cover solution)



walls= 100 mm

base slab thickness 800 mm

haunch 350 mm by 350 mm

Calculated Quantities

excavation=	394.3	m3	
concrete=	500.3023	m3	
rebar=	60.0	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	-23.14943	m2	
SP&L<=4.6m deep	102.4	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	604.2393	m2	

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	394.3	60	23655.97
concrete	m3	500.3023	190.0	95057.44
rebar	tonnes	60.0	1600	96058.04
formwork/falsework	m2	-23.14943	140	-3240.92
SP&L<=4.6m deep	m2	102.4	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	604.2393	30	18127.18
			Total	229657.7

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel

Summary of Costs

Markup for adjacent 0 %

Section	Cost
1	1589250
2	1442071
3	1225243
4	975887.9
5	788589
6	648806.9
7	525582
8	414171
9	314573.9
10	229657.7
Sub-total	8153832

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: South Approach
Option: Bored Rail Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient 0 %

+ sloping same way as track/road
- sloping against track/road

Track/Road Gradient 1.663 %

Ground elevation at portal 100 m

Bottom of slab elevation at portal 86.95 m

Total length= 784.7264 m

Total Cost=$ 8.2 M

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel

UNIT RATES

Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel

UNIT RATES

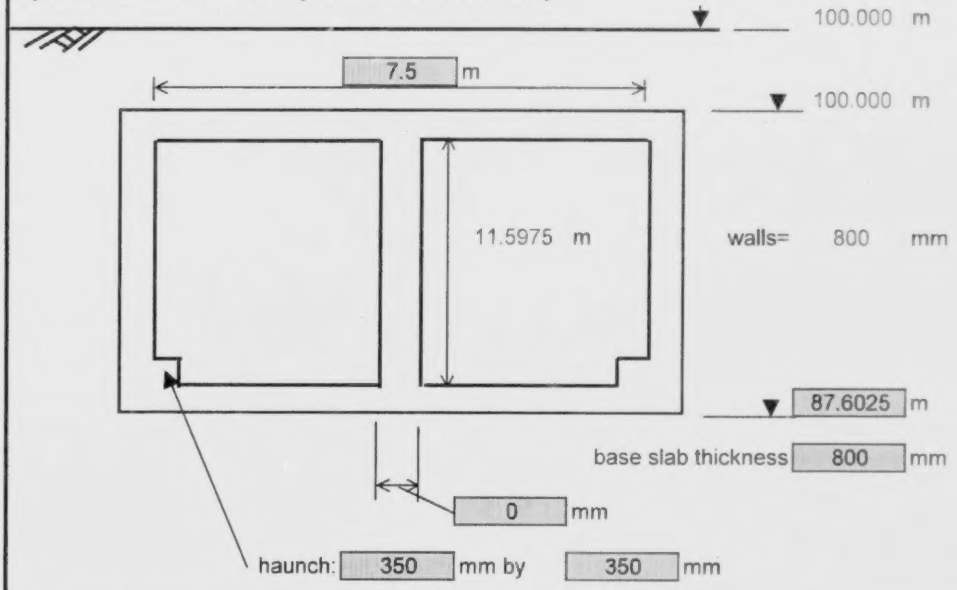
Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section 1**

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
11.5975 m
walls= 800 mm
87.6025 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	8853.1	m3	
concrete=	2046.645	m3	
rebar=	245.6	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1820.173	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1945.7	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	714.101	m2	

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
Bored Rail Tunnel	**Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	8853.1	60	531184
concrete	m3	2046.645	190.0	388862.5
rebar	tonnes	245.6	1600	392955.8
formwork/falsework	m2	1820.173	140	254824.2
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	1945.7	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	714.101	30	21423.03
			Total	1589250

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
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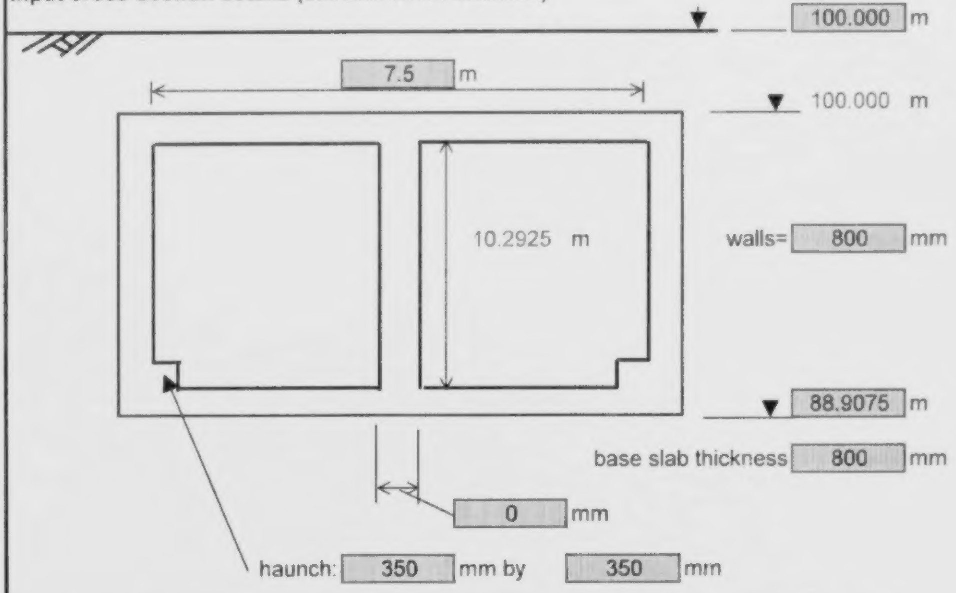
Section Cut and Cover
Length of section: 78.47264 m
Section **2**

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
10.2925 m
walls= 800 mm
88.9075 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	7921.2	m3	
concrete=	1882.794	m3	
rebar=	225.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1615.359	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1740.9	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	714.101	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

Calculated costs

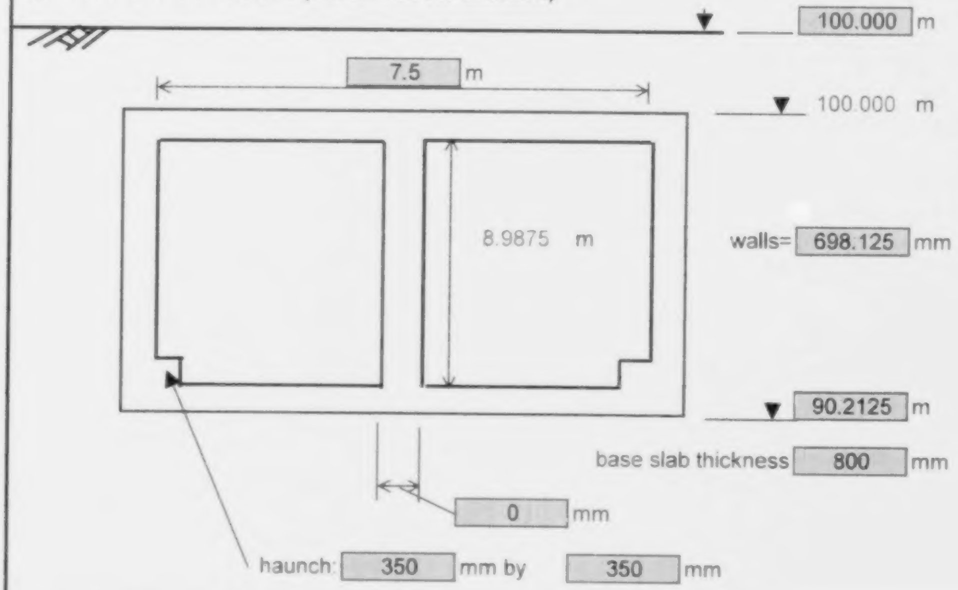
Item	Unit	Quantity	Rate	Cost
excavation	m3	7921.2	60	475269.9
concrete	m3	1882.794	190.0	357730.9
rebar	tonnes	225.9	1600	361496.5
formwork/falsework	m2	1615.359	140	226150.3
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	1740.9	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	714.101	30	21423.03
			Total	1442071

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 78.47264 m
Section 3

Input cross-section details (cut and cover solution)



100.000 m

7.5 m

100.000 m

walls= 698.125 mm

90.2125 m

base slab thickness 800 mm

0 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	6832.8	m3	
concrete=	1562.453	m3	
rebar=	187.5	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1410.546	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1536.1	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	698.1122	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

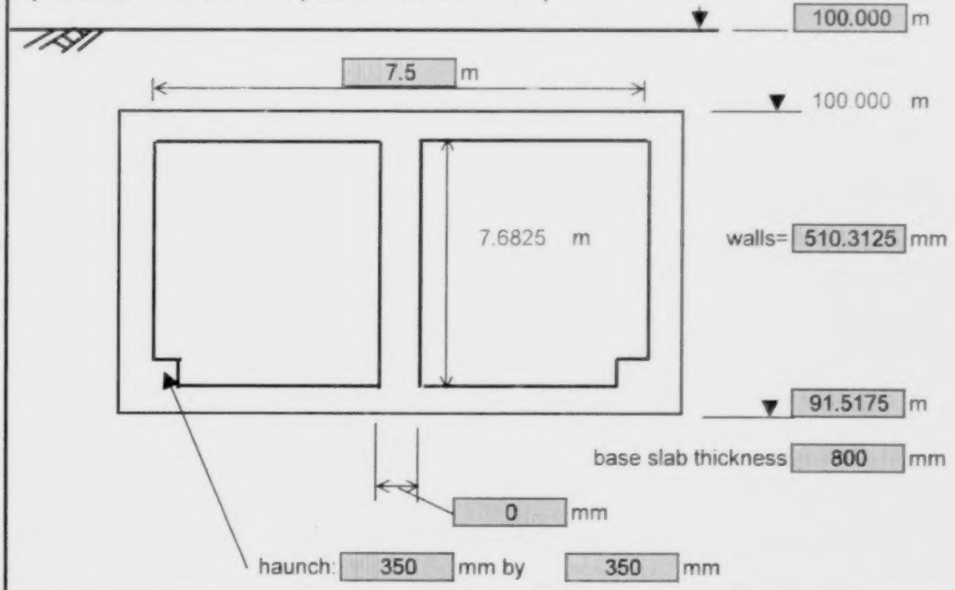
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	6832.8	60	409966.4
concrete	m3	1562.453	190.0	296866
rebar	tonnes	187.5	1600	299990.9
formwork/falsework	m2	1410.546	140	197476.4
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1536.1	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	698.1122	30	20943.37
			Total	1225243

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
Bored Rail Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section** **4**

Input cross-section details (cut and cover solution)



walls= 510.3125 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	5671.7	m3	
concrete=	1169.435	m3	
rebar=	140.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1205.732	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1331.3	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	668.6359	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

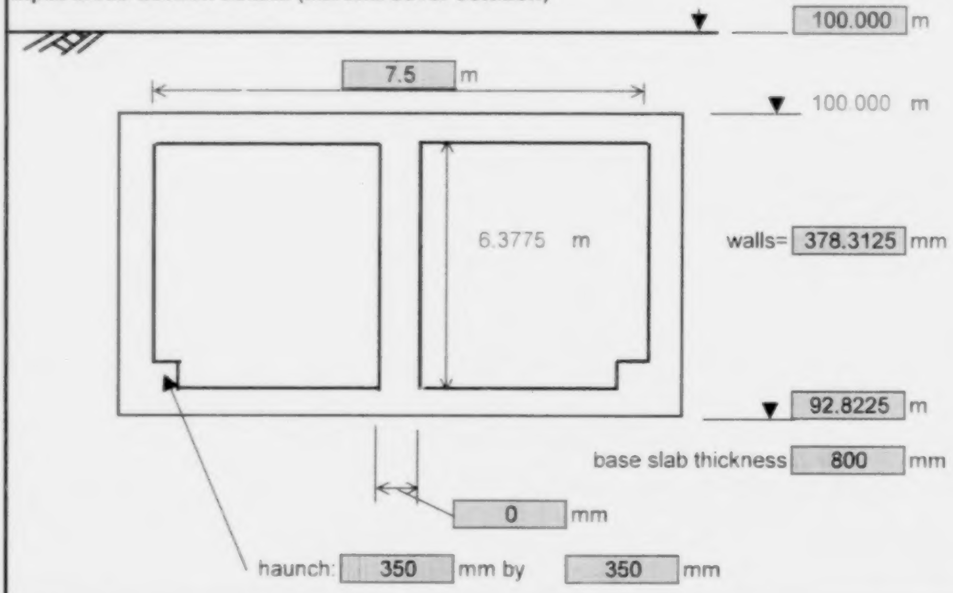
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	5671.7	60	340302.3
concrete	m3	1169.435	190.0	222192.6
rebar	tonnes	140.3	1600	224531.5
formwork/falsework	m2	1205.732	140	168802.5
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1331.3	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	668.6359	30	20059.08
			Total	975887.9

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section 5**

Input cross-section details (cut and cover solution)



walls= 378.3125 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	4650.4	m3	
concrete=	916.2211	m3	
rebar=	109.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1000.919	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1126.5	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	647.9192	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

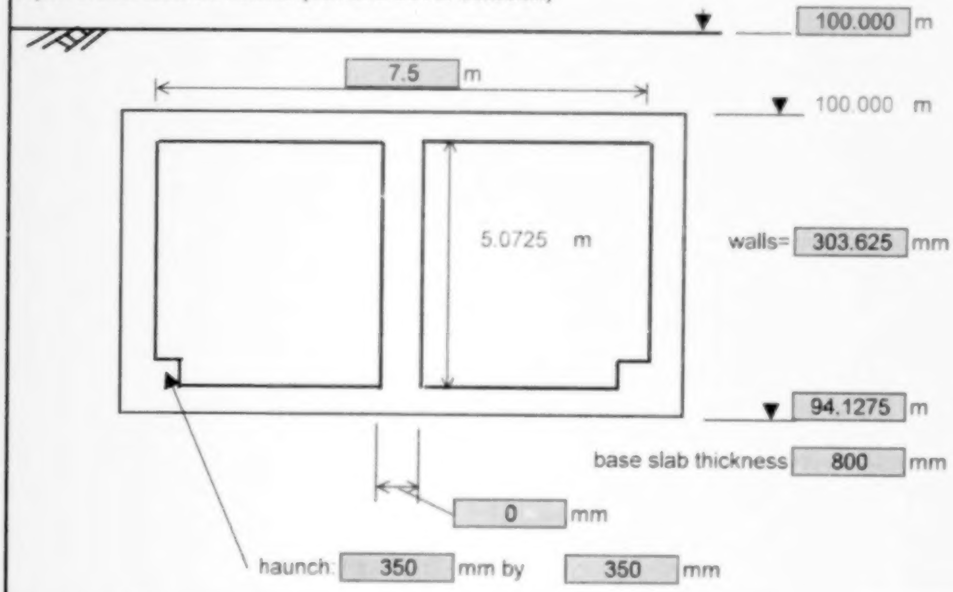
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	4650.4	60	279026.4
concrete	m3	916.2211	190.0	174082
rebar	tonnes	109.9	1600	175914.5
formwork/falsework	m2	1000.919	140	140128.6
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1126.5	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	647.9192	30	19437.57
			Total	788589

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section 6**

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
5.0725 m
walls= 303.625 mm
94.1275 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	3736.1	m3	
concrete=	769.901	m3	
rebar=	92.4	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	796.1049	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	921.7	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	636.1973	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel

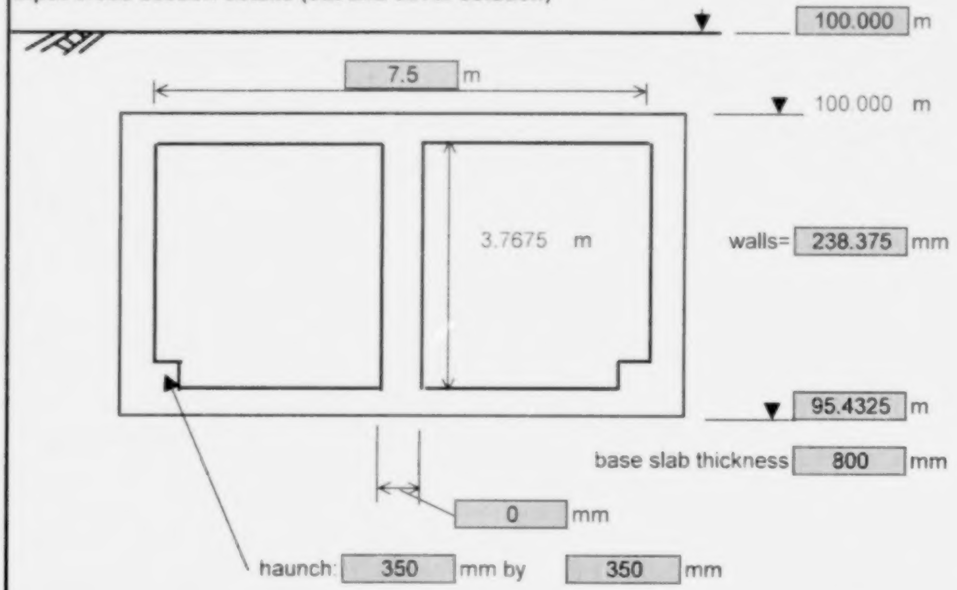
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	3736.1	60	224164.1
concrete	m3	769.901	190.0	146281.2
rebar	tonnes	92.4	1600	147821
formwork/falsework	m2	796.1049	140	111454.7
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	921.7	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	636.1973	30	19085.92
			Total	648806.9

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section 7**

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
3.7675 m
walls= 238.375 mm
95.4325 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	2859.1	m3	
concrete=	660.9402	m3	
rebar=	79.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	591.2913	m2	
SP&L<=4.6m deep	716.8	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	625.9566	m2	

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
Bored Rail Tunnel	**Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	2859.1	60	171543.4
concrete	m3	660.9402	190.0	125578.6
rebar	tonnes	79.3	1600	126900.5
formwork/falsework	m2	591.2913	140	82780.79
SP&L<=4.6m deep	m2	716.8	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	625.9566	30	18778.7
			Total	525582

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
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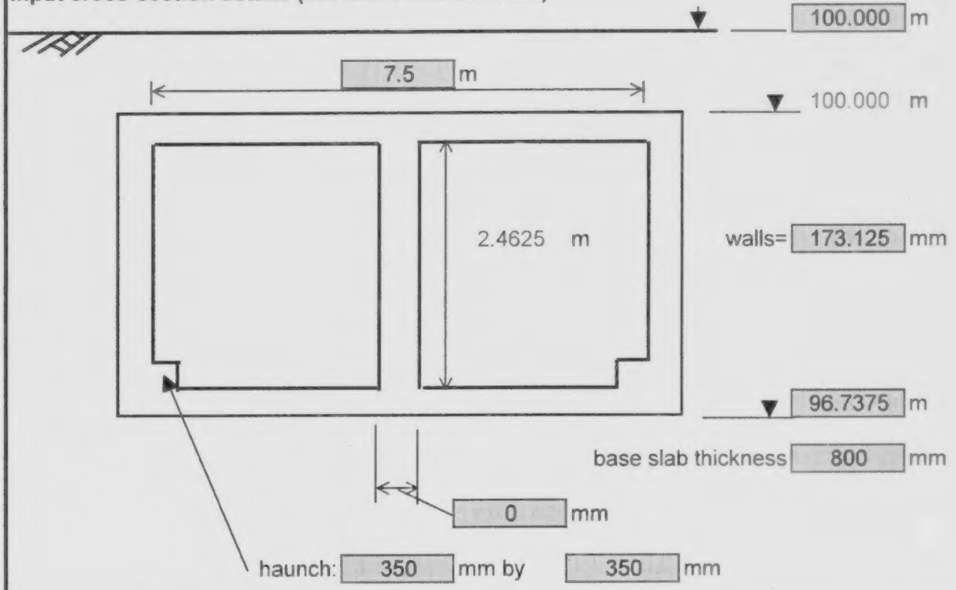
Section Cut and Cover
Length of section: 78.47264 m

Section 8

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
2.4625 m
walls= 173.125 mm
96.7375 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	2008.8	m3	
concrete=	578.7075	m3	
rebar=	69.4	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	386.4778	m2	
SP&L<=4.6m deep	512.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	615.716	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	2008.8	60	120526.4
concrete	m3	578.7075	190.0	109954.4
rebar	tonnes	69.4	1600	111111.8
formwork/falsework	m2	386.4778	140	54106.89
SP&L<=4.6m deep	m2	512.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	615.716	30	18471.48
			Total	414171

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
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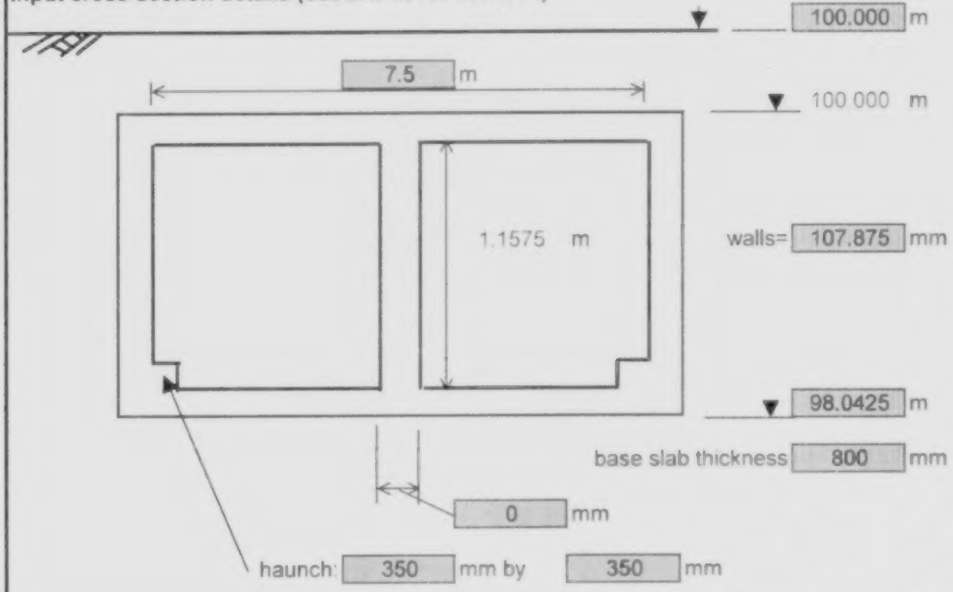
Section Cut and Cover
Length of section: 78.47264 m **Section** 9

Input cross-section details (cut and cover solution)



100.000 m

7.5 m

100.000 m

1.1575 m

walls= 107.875 mm

98.0425 m

base slab thickness 800 mm

0 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	1185.2	m3	
concrete=	523.203	m3	
rebar=	62.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	181.6642	m2	
SP&L<=4.6m deep	307.2	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	605.4753	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

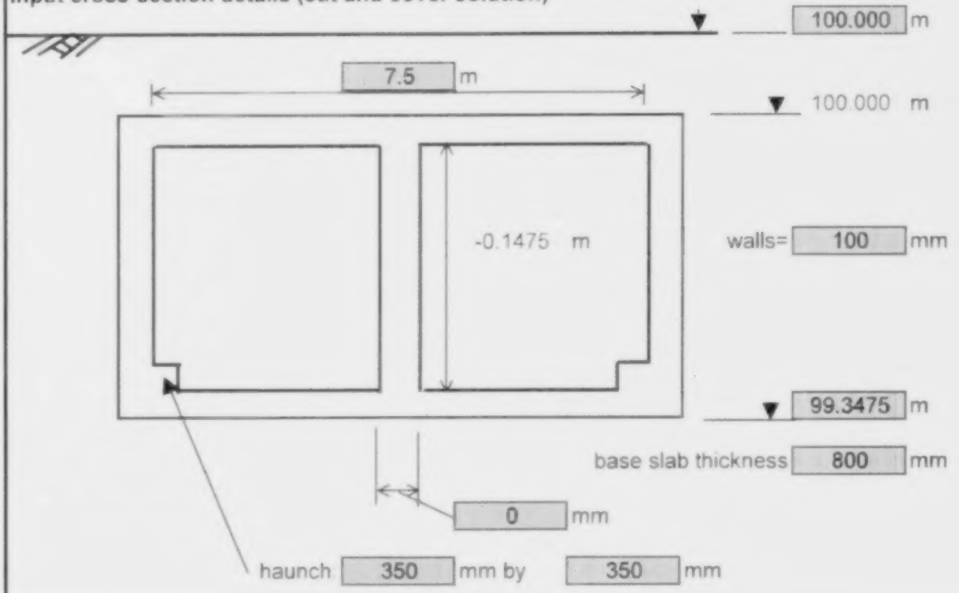
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	1185.2	60	71113.07
concrete	m3	523.203	190.0	99408.58
rebar	tonnes	62.8	1600	100455
formwork/falsework	m2	181.6642	140	25432.98
SP&L<=4.6m deep	m2	307.2	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	605.4753	30	18164.26
			Total	314573.9

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section** 10

Input cross-section details (cut and cover solution)



walls= 100 mm

base slab thickness 800 mm

haunch 350 mm by 350 mm

Calculated Quantities

excavation=	394.3	m3	
concrete=	500.3023	m3	
rebar=	60.0	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	-23.14943	m2	
SP&L<=4.6m deep	102.4	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	604.2393	m2	

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 2 of 2

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	394.3	60	23655.97
concrete	m3	500.3023	190.0	95057.44
rebar	tonnes	60.0	1600	96058.04
formwork/falsework	m2	-23.14943	140	-3240.92
SP&L<=4.6m deep	m2	102.4	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	604.2393	30	18127.18
			Total	229657.7

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel

Summary of Costs

Markup for adjacent 0 %

Section	Cost
1	1589250
2	1442071
3	1225243
4	975887.9
5	788589
6	648806.9
7	525582
8	414171
9	314573.9
10	229657.7
Sub-total	8153832

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Lane Bored Railway Tunnel
Tunnel Structural Finishes

Date: June 07, 2004
Calculation by: A.White

Quantity Take-off

Concrete

Element	Nr.	L(m)	b(m)	d(m)	Concrete Qty(m3)		Rebar Qty(m3)	
1	1	6535	0.3	5.9	11567		1388.0	
2	1	6535	1.2	0.3	2352.6		282.3	
3	1	6535	1.2	0.3	2352.6		282.3	
					16272	m3	1670	t

Formwork/falsework

Element	Nr.	L(m)	d(m)	Faces	Area(m2)	
1	1	6535	5.9	2	77113	
2	1	6535	1.2	1	7842	
3	1	6535	1.2	1	7842	
					92797	m2

Rates

Concrete	m3	190
Formwork	m2	140
Reinforcement	t	1600

Costs

Concrete	m3	16272	m3	at	190	=	3,091,709
Formwork	m2	92797	m2	at	140	=	12,991,580
Reinforcement	t	1670	t	at	1600	=	2,672,554
						$	18,755,842

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Lane Bored Railway Tunnel
Tunnel Structural Finishes

Date: June 07, 2004
Calculation by: A White

Quantity Take-off

Concrete

Element	Nr.	L(m)	b(m)	d(m)	Concrete Qty(m3)		Rebar Qty(m3)	
1	1	6535	0.3	5.9	11567		1388.0	
2	1	6535	1.2	0.3	2352.6		282.3	
3	1	6535	1.2	0.3	2352.6		282.3	
					16272	m3	1670	t

Formwork/falsework

Element	Nr.	L(m)	d(m)	Faces	Area(m2)	
1	1	6535	5.9	2	77113	
2	1	6535	1.2	1	7842	
3	1	6535	1.2	1	7842	
					92797	m2

Rates

Concrete	m3	190
Formwork	m2	140
Reinforcement	t	1600

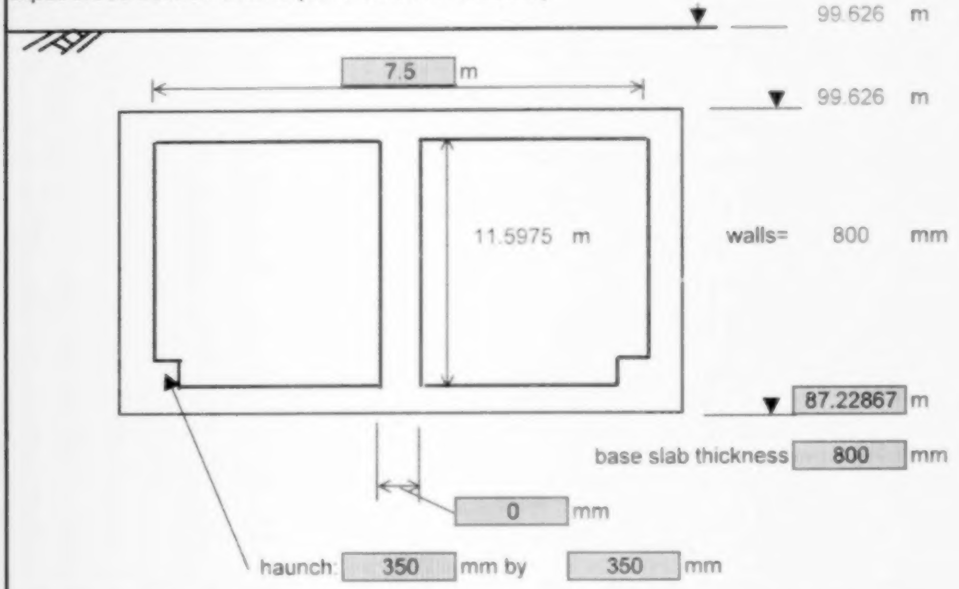
Costs

Concrete	m3	16272	m3	at	190	=	3,091,709
Formwork	m2	92797	m2	at	140	=	12,991,580
Reinforcement	t	1670	t	at	1600	=	2,672,554
						$	18,755,842

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 33.98438 m **Section 1**

Input cross-section details (cut and cover solution)


99.626 m
7.5 m
99.626 m
11.5975 m
walls= 800 mm
87.22867 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	3834.0	m3	
concrete=	886.3465	m3	
rebar=	106.4	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	788.2676	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	842.6	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	309.2578	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	3834.0	60	230041.4
concrete	m3	886.3465	190.0	168405.8
rebar	tonnes	106.4	1600	170178.5
formwork/falsework	m2	788.2676	140	110357.5
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	842.6	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	309.2578	30	9277.734
			Total	688261

Newfoundland Fixed Link Pre-feasibility Study
North Approach
Bored Rail Tunnel

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Calculations by: ANW
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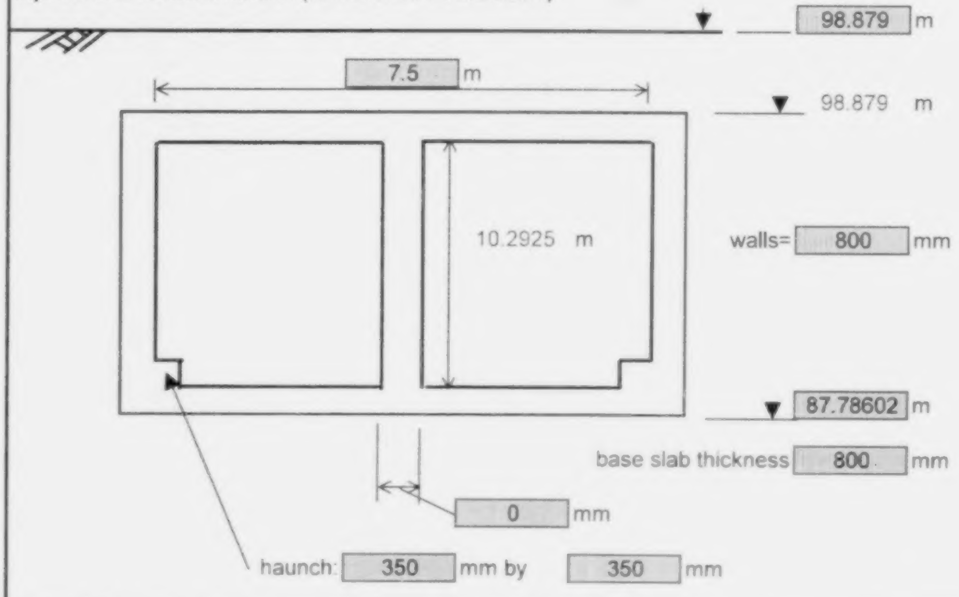
Section Cut and Cover
Length of section: 33.98438 m
Section 2

Input cross-section details (cut and cover solution)



98.879 m
7.5 m
98.879 m
10.2925 m
walls= 800 mm
87.78602 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	3430.4	m3	
concrete=	815.3871	m3	
rebar=	97.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	699.5684	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	753.9	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	309.2578	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

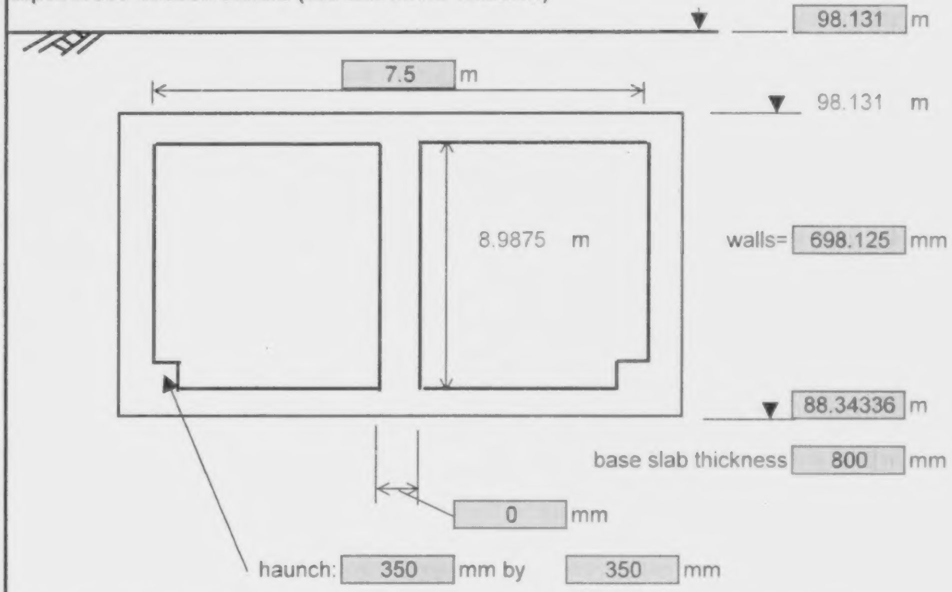
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	3430.4	60	205826.5
concrete	m3	815.3871	190.0	154923.6
rebar	tonnes	97.8	1600	156554.3
formwork/falsework	m2	699.5684	140	97939.57
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	753.9	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	309.2578	30	9277.734
			Total	624521.7

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 33.98438 m **Section** 3

Input cross-section details (cut and cover solution)



98.131 m
7.5 m
98.131 m
8.9875 m
walls= 698.125 mm
88.34336 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	2959.1	m3	
concrete=	676.656	m3	
rebar=	81.2	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	610.8691	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	665.2	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	302.3335	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	2959.1	60	177545.3
concrete	m3	676.656	190.0	128564.6
rebar	tonnes	81.2	1600	129917.9
formwork/falsework	m2	610.8691	140	85521.68
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	665.2	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	302.3335	30	9070.005
			Total	530619.6

Newfoundland Fixed Link Pre-feasibility Study
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Bored Rail Tunnel

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Calculations by: ANW
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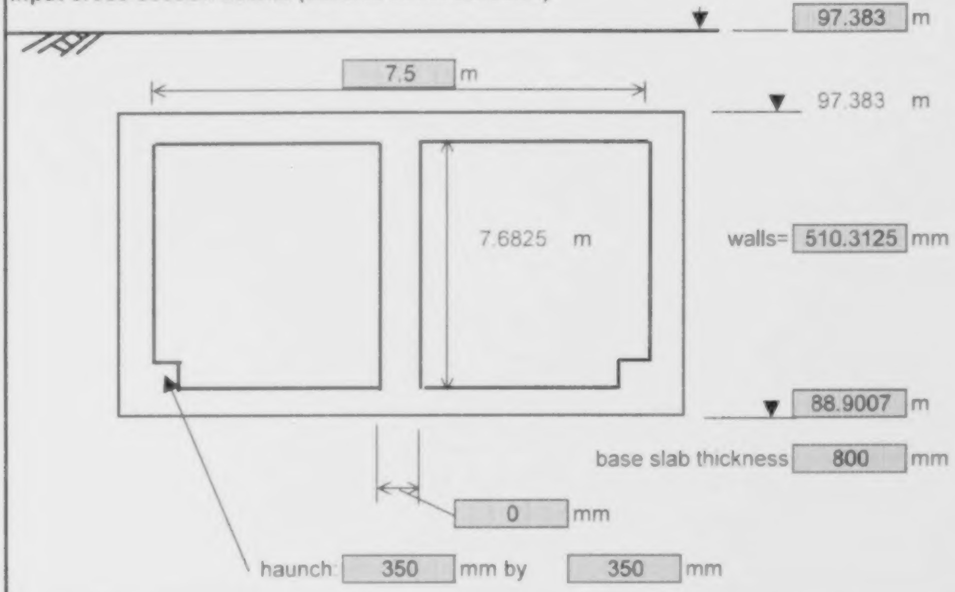
Section Cut and Cover
Length of section: 33.98438 m

Section 4

Input cross-section details (cut and cover solution)


97.383 m
7.5 m
97.383 m
7.6825 m
walls= 510.3125 mm
88.9007 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	2456.3	m3	
concrete=	506.4505	m3	
rebar=	60.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	522.1699	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	576.5	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	289.5681	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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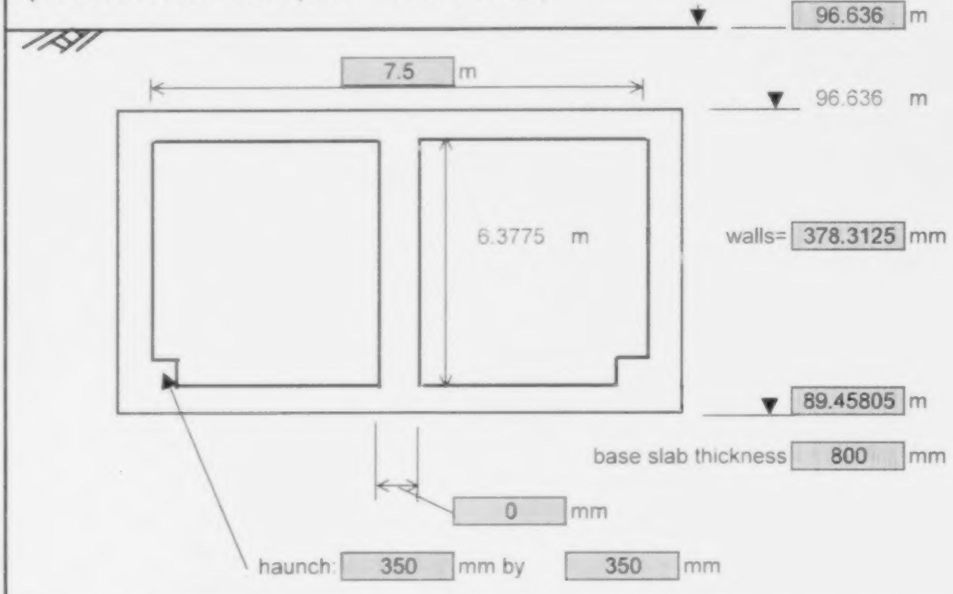
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	2456.3	60	147375.7
concrete	m3	506.4505	190.0	96225.6
rebar	tonnes	60.8	1600	97238.5
formwork/falsework	m2	522.1699	140	73103.79
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	576.5	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	289.5681	30	8687.043
			Total	422630.6

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 33.98438 m **Section** **5**

Input cross-section details (cut and cover solution)



walls= 378.3125 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	2014.0	m3	
concrete=	396.7905	m3	
rebar=	47.6	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	433.4707	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	487.8	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	280.5962	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	2014.0	60	120838.8
concrete	m3	396.7905	190.0	75390.2
rebar	tonnes	47.6	1600	76183.79
formwork/falsework	m2	433.4707	140	60685.9
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	487.8	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	280.5962	30	8417.887
			Total	341516.5

Newfoundland Fixed Link Pre-feasibility Study
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Calculations by: ANW
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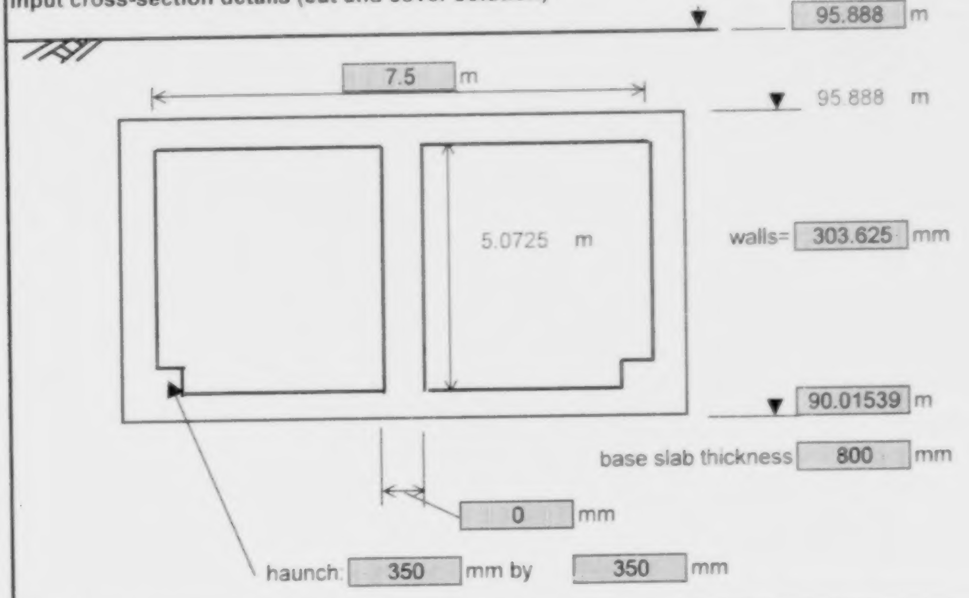
Section Cut and Cover
Length of section: 33.98438 m
Section 6

Input cross-section details (cut and cover solution)



95.888 m
7.5 m
95.888 m
5.0725 m
walls= 303.625 mm
90.01539 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	1618.0	m3	
concrete=	333.4233	m3	
rebar=	40.0	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	344.7715	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	399.1	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	275.5198	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	1618.0	60	97079.41
concrete	m3	333.4233	190.0	63350.42
rebar	tonnes	40.0	1600	64017.27
formwork/falsework	m2	344.7715	140	48268.01
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	399.1	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	275.5198	30	8265.595
			Total	280980.7

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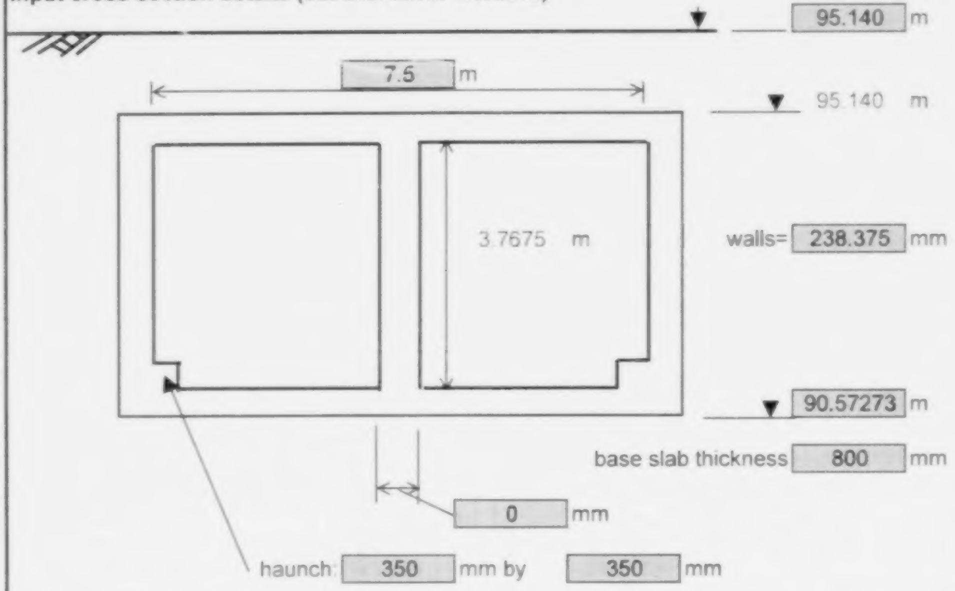
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 33.98438 m **Section** 7

Input cross-section details (cut and cover solution)



95.140 m

7.5 m

95.140 m

3.7675 m

walls= 238.375 mm

90.57273 m

base slab thickness 800 mm

0 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	1238.2	m3	
concrete=	286.2353	m3	
rebar=	34.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	256.0723	m2	
SP&L<=4.6m deep	310.4	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	271.0849	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	1238.2	60	74290.81
concrete	m3	286.2353	190.0	54384.7
rebar	tonnes	34.3	1600	54957.18
formwork/falsework	m2	256.0723	140	35850.12
SP&L<=4.6m deep	m2	310.4	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	271.0849	30	8132.546
			Total	227615.4

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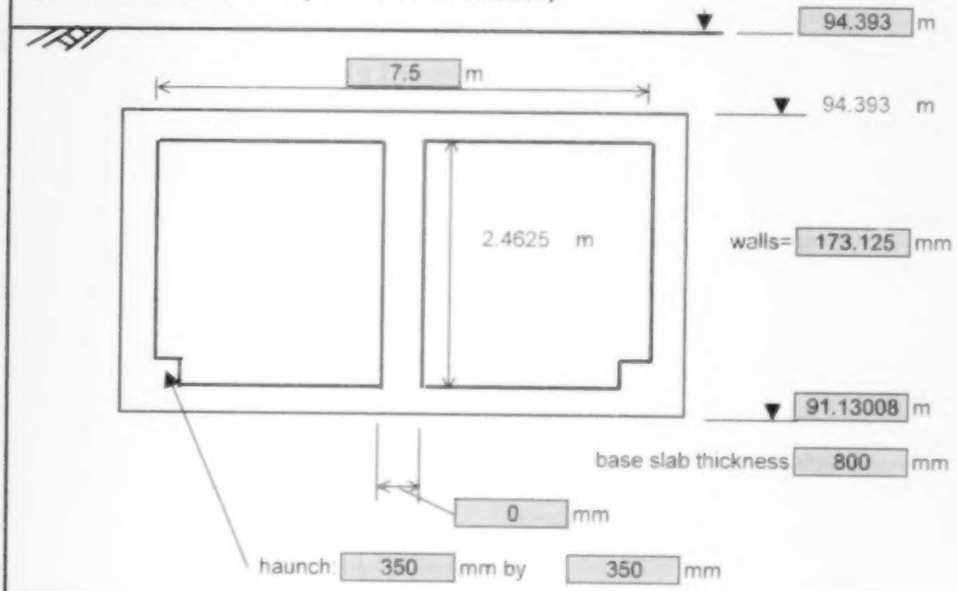
Section Cut and Cover
Length of section: 33.98438 m **Section 8**

Input cross-section details (cut and cover solution)



94.393 m
7.5 m
94.393 m
2.4625 m
walls= 173.125 mm
91.13008 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	869.9	m3	
concrete=	250.6226	m3	
rebar=	30.1	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	167.373	m2	
SP&L<=4.6m deep	221.7	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	266.6499	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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Calculated costs

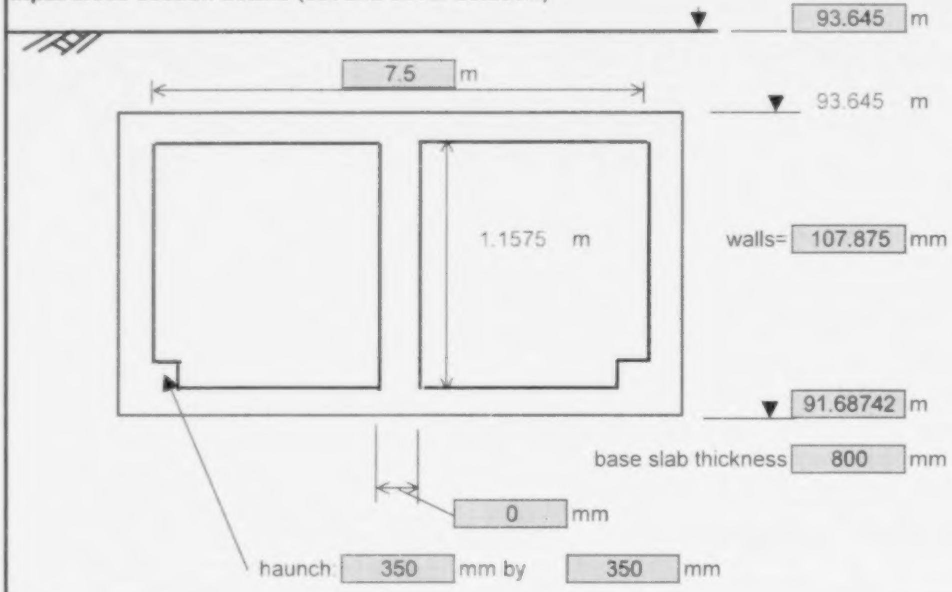
Item	Unit	Quantity	Rate	Cost
excavation	m3	869.9	60	52196.72
concrete	m3	250.6226	190.0	47618.28
rebar	tonnes	30.1	1600	48119.53
formwork/falsework	m2	167.373	140	23432.23
SP&L<=4.6m deep	m2	221.7	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	266.6499	30	7999.497
			Total	179366.3

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
North Approach	**Calculations by:** ANW
Bored Rail Tunnel	**Page 1 of 2**

Section Cut and Cover

Length of section: 33.98438 m **Section** 9

Input cross-section details (cut and cover solution)


93.645 m
7.5 m
93.645 m
1.1575 m
walls= 107.875 mm
91.68742 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	513.3	m3	
concrete=	226.5851	m3	
rebar=	27.2	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	78.67383	m2	
SP&L<=4.6m deep	133.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	262.2149	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
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Bored Rail Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	513.3	60	30797.14
concrete	m3	226.5851	190.0	43051.16
rebar	tonnes	27.2	1600	43504.33
formwork/falsework	m2	78.67383	140	11014.34
SP&L<=4.6m deep	m2	133.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	262.2149	30	7866.448
			Total	136233.4

Newfoundland Fixed Link Pre-feasibility Study
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Bored Rail Tunnel

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Calculations by: ANW
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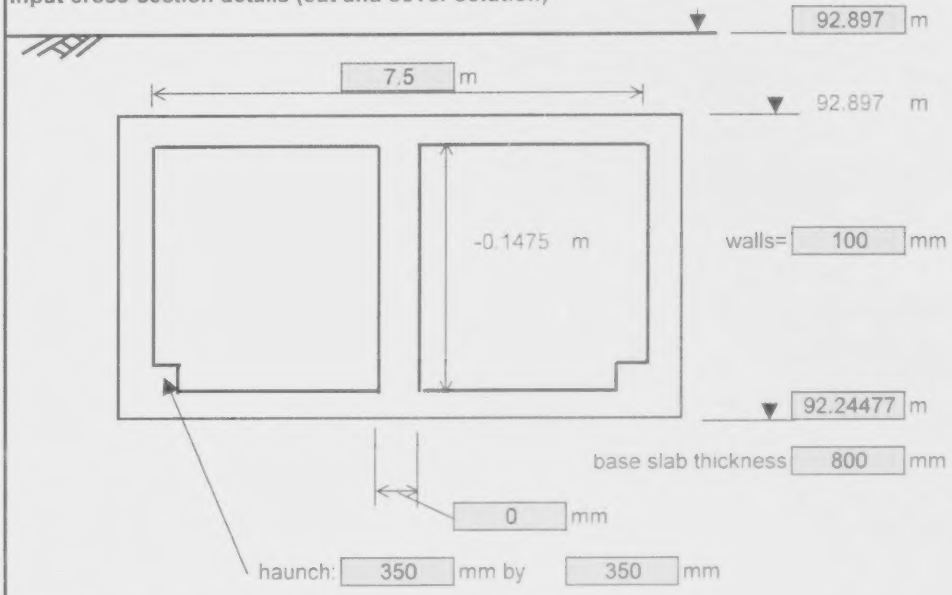
Section Cut and Cover
Length of section: 33.98438 m

Section 10

Input cross-section details (cut and cover solution)


92.897 m
7.5 m
92.897 m
-0.1475 m
walls= 100 mm
92.24477 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

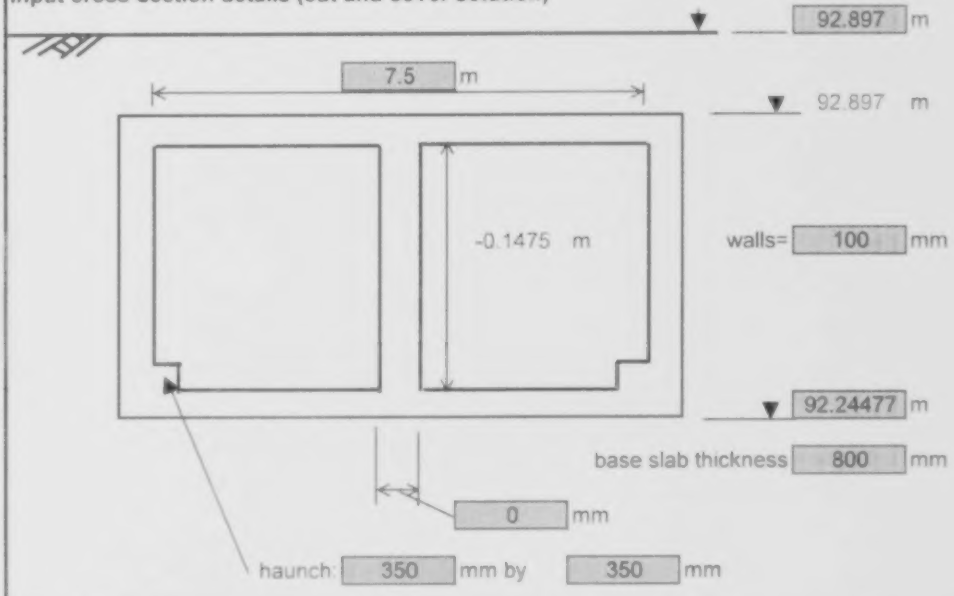
Calculated Quantities

excavation=	170.7	m3	
concrete=	216.6674	m3	
rebar=	26.0	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	-10.02539	m2	
SP&L<=4.6m deep	44.3	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	261.6797	m2	

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
North Approach	**Calculations by:** ANW
Bored Rail Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 33.98438 m **Section** 10

Input cross-section details (cut and cover solution)


92.897 m
7.5 m
92.897 m
-0.1475 m
walls= 100 mm
92.24477 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	170.7	m3	
concrete=	216.6674	m3	
rebar=	26.0	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	-10.02539	m2	
SP&L<=4.6m deep	44.3	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	261.6797	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	170.7	60	10244.76
concrete	m3	216.6674	190.0	41166.8
rebar	tonnes	26.0	1600	41600.14
formwork/falsework	m2	-10.02539	140	-1403.555
SP&L<=4.6m deep	m2	44.3	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	261.6797	30	7850.391
			Total	99458.54

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel

Summary of Costs

Markup for adjacent 0 %

Section	Cost
1	688261
2	624521.7
3	530619.6
4	422630.6
5	341516.5
6	280980.7
7	227615.4
8	179366.3
9	136233.4
10	99458.54
Sub-total	3531204

Newfoundland Fixed Link Pre-feasibility Study
Tunnel Drainage
Bored Railway Tunnel
Drainage Costs

Page 1 of 1
Calculation by: ANW
Date: June 8, 2004

Sump Sizing

Assume inflow to tunnel of 1 litres/m2/24hours

Tunnel length= 28000 m
Tunnel diameter= 7.5 m

24 hour inflow= 1237002 litres = 1237 m3
assume same again for firefighting= 1237 m3

Required sump capacity= 2474 m3

Assumed sump diameter= 6 m
Assumed number of sump structures= 2 m

Required length of each sump= 44 m

Piping

Assume 300 mm diameter steel pipe connecting each sump to the portal areas
Number of pipes= 1
Assume sumps located at 1/3 and 2/3 of tunnel length

Total length of piping= 18967 m

Rates

Sump construction-$	17795	/m of sump	
Pipe-$	265	/m of pipe	
Pipe installation labour -$	29	/m of pipe	(assume 6 man crew installing 100m/day)
Pipe installation equipment-$	10	/m of pipe	(assume $1000/day for equipment)
Pumps-$	125000	/pump	

Costs

Item	Unit	Qty	Rate	$-Cost
Sump construction	m	88	17795	1,565,960
Pipe	m	18967	265	5,026,167
Pipe installation	m	18967	29	546,240
Equipment	m	18967	10	189,667
Pumps	Nr	4	125000	500,000
			Total	7,828,033

Newfoundland Fixed Link Pre-feasibility Study
Tunnel Drainage
Bored Railway Tunnel
Drainage Costs

Page 1 of 1
Calculation by: ANW
Date: June 8, 2004

Sump Sizing

Assume inflow to tunnel of 1 litres/m2/24hours

Tunnel length= 28000 m
Tunnel diameter= 7.5 m

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Pipe-$	265	/m of pipe	
Pipe installation labour -$	29	/m of pipe	(assume 6 man crew installing 100m/day)
Pipe installation equipment-$	10	/m of pipe	(assume $1000/day for equipment)
Pumps-$	125000	/pump	

Costs

Item	Unit	Qty	Rate	$-Cost
Sump construction	m	88	17795	1,565,960
Pipe	m	18967	265	5,026,167
Pipe installation	m	18967	29	546,240
Equipment	m	18967	10	189,667
Pumps	Nr	4	125000	500,000
			Total	7,828,033

Newfoundland Fixed Link
Pre-feasibility Study
Preferred Fixed Link Option - TBM Bored Railway Tunnel
Basis of Estimate

Scope

Estimate includes:

- mobilisation of equipment and materials
- TBM bored tunnel excavation and lining
- TBM bored tunnel finishes
- north and south approaches to TBM bored rail tunnel
- north and south rail terminals including passenger facilities, maintenance facilities, tolling areas
- tunnel trackwork, drainage, ventilation, mechanical & electrical items
- shuttle trains, signalling, and OCS system
- allowances for indirect costs, contractor profit, and risk allowances

Estimate does not include:

- land purchase costs
- approach roads to the terminal areas (addressed separately)
- provision for bringing electrical power to the facility

Assumptions

Principal Assumptions:

- labour wages in accordance with Local 2003 Collective Agreement for Newfoundland & Labrador
- 7.5 metre internal diameter tunnel driven from Newfoundland side using an EPB type tunnel boring machine configured for rock
- tunnel approximately 26.3 kilometres in length
- 3 eight hour shifts 5 days per week for tunnelling operations
- tunnel lined with bolted precast concrete segmental tunnel liner
- average tunnelling advance rate of 81 metres per week
- tunnel drive encounters 14 faults each 100 metres wide where advance rate decreases by approximately 60%
- rail mounted loco and muck car system used for removal of tunnel spoil
- longitudinal system used for ventilation of the tunnel (permanent facility)

Costs

Cost assumptions

- All costs in 2004 Canadian dollars
- HST not included

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Newfoundland Fixed Link Pre-feasibility - TBM Bored Railway Tunnel - Cost Summary

BORED TUNNEL CONSTRUCTION COSTS		
ITEM	UNIT	MAIN TUNNEL
MOBILIZATION & DEMOBILIZATION	LS	8,000,000
TUNNELLING	LS	375,031,000
TUNNEL FINISHES	LS	75,539,979
NORTH APPROACH STRUCTURES	LS	7,770,000
SOUTH APPROACH STRUCTURES	LS	8,150,000
RAIL TRACK	LS	13,923,100
TUNNEL DRAINAGE	LS	7,820,000
UTILITY DIVERSIONS	LS	1,000,000
MONITORING	LS	1,000,000
SUBTOTAL CIVIL		**$498,234,079**
CIVIL CONTINGENCIES		
CONTINGENCY	40%	$199,293,632
TOTAL CIVIL		**$697,527,711**
M&E, ROLLING STOCK, RAIL HARDWARE AND FINISHING WORK		
ROLLING STOCK, TERMINALS, OCS, ETC	LS	$48,000,000
VENTILATION EQUIPMENT	LS	$3,000,000
VENTILATION SHAFTS AND BUILDINGS x 2	LS	$0
FIRE SUPPRESSION SYSTEM	LS	$2,000,000
CONTROL CENTRE	LS	$1,000,000
SIGNALLING	LS	$1,000,000
LIGHTING	LS	$1,000,000
CCTV SYSTEM	LS	$0
GAS DETECTION	LS	$900,000
SUBSTATION, GENERATORS, UPS	LS	$2,000,000
SUBTOTAL M&E AND FINISHING		**$58,900,000**
CONTINGENCIES	20%	$11,780,000
TOTAL M&E AND FINISHING		**$70,680,000**
TOTAL CIVIL, M&E AND FINISHING		**$768,207,711**
ALLOWANCES		
CONTRACTOR OH	15%	$115,231,157
CONTRACTOR PROFIT	15%	$115,231,157
CONSTRUCTION TOTAL		**$999,000,000**
PRE-CONSTRUCTION AND SUPERVISION		
FEASIBILITY STUDY	LS	$11,000,000
ENVIRONMENTAL ASSESSMENT	LS	$4,000,000
DESIGN	5%	$49,950,000
CONSTRUCTION MANAGEMENT	10%	$99,900,000
OWNERS COSTS	2%	$19,980,000
PRE-CONSTRUCTION TOTAL		$184,830,000
GRAND TOTAL		**$1,183,830,000**

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Newfoundland Fixed Link Pre-feasibility - TBM Bored Railway Tunnel - Civil Costs

ITEM	UNIT	QTY	RATE	TOTAL
MOBILIZATION	LS	1.00	$8,000,000	$8,000,000
TUNNELLING				
- TBM launch shaft	LS	1.00	$0	$0
- Set-up TBM	LS	1.00	$1,474,000	$1,474,000
- Tunnel drive	LS	1.00	$368,001,000	$368,001,000
- TBM maintenance	LS	1.00	$960,000	$960,000
- Remove TBM	LS	1.00	$812,000	$812,000
- Clean tunnel	LS	1.00	$3,784,000	$3,784,000
- Structural finishes	LS	1.00	$75,539,979	$75,539,979
- TBM reception shaft	LS	1.00	$0	$0
NORTH APPROACH STRUCTURES				
- Cut and cover approach	LS	1.00	$7,770,000	$7,770,000
SOUTH APPROACH STRUCTURES				
- cut and cover approach	LS	1.00	$8,150,000	$8,150,000
DRAINAGE				
Drainage sumps and piping	LS	1.00	$7,820,000	$7,820,000
RAIL TRACK				
- bored tunnel	m2	40,050.00	$20	$801,000
- north approach	m2	31,150.00	$20	$623,000
- south approach	m2	1,602.00	$30	$48,060
SUB-TOTAL				**$483,783,039**

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Detailed Cost Estimate Report

Version 2.6

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Project:	Newfoundland Fixed Link Pre-feasibility Study	**Project Number:**	213789
Estimate Description:	Set-up TBM	**Parent Estimate ID:**	1563
Tunnel Name:	Single Rail Bored	**Project Phase:**	Conceptual
Construction Activity:	Erect TBM Only	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	May 31, 2004
Estimate Definition ID:	2636	**Tunnel Characteristics ID:**	843

Tunnel Characteristics

Finished Diameter: 7.5 m

Activity Details

Shift Arrangement 3 - 8 hour shifts x 7 days per week

Duration of Activity 4.5 Weeks

Total Number of Shifts 94.5

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor					
Pit boss	52.29	$/hr	756.00	1.00	39,531
Tunnel miner	48.89	$/hr	756.00	2.00	73,922
Shaft bottom	48.44	$/hr	756.00	3.00	109,862
Tunnel fitter	49.34	$/hr	756.00	1.00	37,301
Tunnel electrician	49.34	$/hr	756.00	1.00	37,301
Shaft top	47.99	$/hr	756.00	1.00	36,280
Crane operator	49.34	$/hr	756.00	2.00	74,602
Surface laborer	47.99	$/hr	756.00	1.00	36,280
Equipment laborer	48.44	$/hr	756.00	1.00	36,621
				13.00	$481,701
Plant					
Loco	5,000.00	$/wk	4.50	1.00	22,500
Muck cars & grout cars	1,900.00	$/wk	4.50	6.00	51,300
Flat cars	310.00	$/wk	4.50	2.00	2,790
Transformers & switchgear - LV	750.00	$/wk	4.50	1.00	3,375
Small tools	2,600.00	$/wk	4.50	1.00	11,700
Shaft crane	9,000.00	$/wk	4.50	1.00	40,500
Erection crane	10,000.00	$/wk	4.50	1.00	45,000
Compressors	950.00	$/wk	4.50	1.00	4,275
Generators	2,000.00	$/wk	4.50	1.00	9,000
Transformers & switchgear - HV	5,200.00	$/wk	4.50	1.00	23,400
Loaders	2,300.00	$/wk	4.50	1.00	10,350
					$224,190
Consumables					
Electrical power	0.00	$/kwh	756.00	300.00	0
Gas oil	0.00	$/L	0.00	1.00	0

Estimate Definition ID: 2636

Estimated by: ____________________

Printed by: **whit2782, 8/16/04 11:42:50 AM**

Checked by: ____________________

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Lubrication materials	0.00	$/wk	4.50	1.00	0
Filters etc.	0.00	$/wk	4.50	1.00	0
Hydraulic oil	0.00	$/L	0.00	1.00	0
Other consumables	0.00	$/wk	4.50	1.00	0
					$0
Materials					
Temporary materials	2,000.00	$/wk	4.50	1.00	9,000
Thrust frame	5,000.00	$/wk	4.50	1.00	22,500
					$31,500

Total Estimated Cost: $737,391

Estimate Definition ID: 2636

Estimated by: ____________________

Checked by: ____________________

APPENDIX D (7)

BORED RAIL TUNNEL COSTS (2TBM'S)

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Tunnel Estimation Database

Detailed Cost Estimate Report

Version 2.6

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Project:	Newfoundland Fixed Link Pre-feasibility Study	**Project Number:**	213789
Estimate Description:	Drive from Newfland	**Parent Estimate ID:**	2728
Tunnel Name:	Rail Bored 2 TBM NF	**Project Phase:**	Conceptual
Construction Activity:	TBM Tunneling	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	September 13, 2004
Estimate Definition ID:	2736	**Tunnel Characteristics ID:**	885

Tunnel Characteristics

Tunnel Length:	13,161	m
Finished Diameter:	7.5	m
Initial Support Type:	Not Applicable	
Initial Support Thickness:	0	m
Final Lining Thickness:	0.35	m
Grout Thickness:	0.1	m

Theoretical Excavation Volumes

Total Neat Excavation:	729,352	Cubic Metres
Initial Lining Volume:	0	Cubic Metres
Final Lining Volume:	113,599	Cubic Metres
Theoretical Grout Volume:	34,318	Cubic Metres

Normal Excavation/Support Cycle

Excavation Cycle Length:	1.5	Metres
Excavate:	24	Minutes
Erect Support:	27	Minutes
Extend Services:	0	Minutes
Total Cycle Time:	51	Minutes

Difficult Excavation/Support Cycle

Length of Difficult Excavation:	1400	Metres
Excavate:	73	Minutes
Erect Support:	54	Minutes
Extend Services:	0	Minutes
Total Cycle Time:	127	Minutes

Reduction Factors

Machine availability:	80	%
Back up efficiency:	55	%
Planned maintenance:	5	%
Learning curve efficiency:	40	%
Learning curve duration time:	8	Weeks

Learning Curve Rate:	7.1	m/day
Experienced Advance Rate:	17.7	m/day
Difficult Advance Rate:	7.1	m/day

TBM Skidding Through Excavation

Duration of skidding:	0	Weeks
Length of skidding:	0	Metres

Advance Rate and Shift Details

Shift Arrangement:	3 - 8 hour shifts x 7 days per week	
Avg. Drive Advance per Shift:	4.90	Metres
Avg. Drive Advance per Day:	15	Metres
Avg. Drive Advance per Week:	103	Metres
Duration of Tunneling (Incl. Skid):	127.84	Weeks
Total number of shifts (Incl. Skid):	2,685	

	Metres	Days
Learning Curve Drive:	397	56
Experienced Drive:	11,364	642
Difficult Drive:	1,400	197
Skidding Portion:	0	0

Estimate Definition ID: 2736

Estimated by: ____________________

Printed by: whit2782, 9/13/04 3:15:33 PM

Checked by: ____________________

	Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor						
	Pit boss	52.29	$/hr	21,481.00	1.00	1,123,241
	Working foreman	52.29	$/hr	21,481.00	2.00	2,246,483
	Tunnel miner	48.89	$/hr	21,481.00	3.00	3,150,618
	Tunnel laborer	48.44	$/hr	21,481.00	4.00	4,162,159
	Loco driver	49.34	$/hr	21,481.00	3.00	3,179,618
	Shaft bottom	48.44	$/hr	21,481.00	1.00	1,040,540
	TBM operator	49.34	$/hr	21,481.00	1.00	1,059,873
	Tunnel fitter	49.34	$/hr	21,481.00	1.00	1,059,873
	Tunnel electrician	49.34	$/hr	21,481.00	1.00	1,059,873
	Shaft top	47.99	$/hr	21,481.00	2.00	2,061,746
	Crane operator	49.34	$/hr	21,481.00	1.00	1,059,873
	Surface laborer	47.99	$/hr	21,481.00	4.00	4,123,493
	Equipment laborer	48.44	$/hr	21,481.00	4.00	4,162,159
					28.00	$29,489,546
Plant						
	TBM	300,000.00	$/m2	55.42	0.80	13,300,800
	TBM backup	1,430,000.00	$/Nr	1.00	1.00	1,430,000
	Loco	5,000.00	$/wk	127.84	3.00	1,917,600
	Muck cars & grout cars	1,900.00	$/wk	127.84	21.00	5,100,816
	Flat cars	310.00	$/wk	127.84	6.00	237,782
	Manriders	310.00	$/wk	127.84	2.00	79,261
	Track	130.00	$/m	13,161.00	1.00	1,710,930
	Air pipe	30.00	$/m	13,161.00	1.00	394,830
	Water pipe	25.00	$/m	13,161.00	1.00	329,025
	Pump main	50.00	$/m	13,161.00	1.00	658,050
	Cabling	80.00	$/m	13,161.00	1.00	1,052,880
	Lighting	30.00	$/m	13,161.00	1.00	394,830
	Vent ducting	30.00	$/m	13,161.00	1.00	394,830
	Grout mixers	7,100.00	$/wk	127.84	1.00	907,664
	Grout pumps	3,400.00	$/wk	127.84	1.00	434,656
	Grout hoses & pipes	196.00	$/wk	127.84	2.00	50,113
	Transformers & switchgear - LV	750.00	$/wk	127.84	2.00	191,760
	Small tools	2,600.00	$/wk	127.84	1.00	332,384
	Shaft crane	9,000.00	$/wk	127.84	1.00	1,150,560
	Compressors	950.00	$/wk	127.84	1.00	121,448
	Low pressure C/A system	3,800.00	$/wk	127.84	1.00	485,792
	Pipework and controls	655.00	$/wk	127.84	2.00	167,470
	Generators	2,000.00	$/wk	127.84	1.00	255,680
	Transformers & switchgear - HV	5,200.00	$/wk	127.84	1.00	664,768
	Surface fans	800.00	$/wk	127.84	2.00	204,544
	Loaders	2,300.00	$/wk	127.84	2.00	588,064
	Other surface plant	2,600.00	$/wk	127.84	1.00	332,384

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Tunnel C/A system	40,000.00	$/wk	127.84	1.00	5,113,600
					$38,002,522
Consumables					
Electrical power	0.10	$/kwh	21,481.00	3,000.00	6,444,300
Gas oil	0.45	$/L	48,000.00	1.00	21,600
Lubrication materials	90.00	$/wk	127.84	1.00	11,506
TBM spares, cutters	250.00	$/m	13,161.00	1.00	3,290,250
Filters etc.	300.00	$/wk	127.84	1.00	38,352
Hydraulic oil	0.90	$/L	32,000.00	1.00	28,800
Other consumables	160.00	$/wk	127.84	1.00	20,454
Tail seal grease	100.00	$/m	13,161.00	1.00	1,316,100
					$11,171,362
Materials					
Concrete lining rings	8,300.31	$/Nr	8,774.00	1.00	72,826,912
Gaskets	130.00	$/m	13,161.00	1.00	1,710,930
Bolts	12.00	$/Nr	1,765.00	30.00	635,400
Grout	145.00	$/m3	34,318.00	1.00	4,976,110
Grout plugs	0.50	$/Nr	1,765.00	7.00	6,178
Packers	10.00	$/Nr	3,633.00	12.00	435,960
Temporary materials	2,250.00	$/wk	127.84	1.00	287,640
Other materials	0.00	$/t	0.00	1.00	0
					$80,879,129
Subcontracts					
Soil disposal	20.00	$/m3	729,352.00	1.50	21,880,560
					$21,880,560

Total Estimated Cost:	$181,423,120
Total Estimated Cost per Metre:	$13,785
Total Estimated Cost per Week:	$1,419,180
Total Estimated Cost per Shift:	$67,567

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Tunnel Estimating Software

Detailed Cost Estimate Report

Version 2.6

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Project:	Newfoundland Fixed Link Pre-feasibility Study	**Project Number:**	213789
Estimate Description:	Drive from Labrador	**Parent Estimate ID:**	2728
Tunnel Name:	Rail Bored 2 TBM LB	**Project Phase:**	Conceptual
Construction Activity:	TBM Tunneling	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	September 13, 2004
Estimate Definition ID:	2737	**Tunnel Characteristics ID:**	886

Tunnel Characteristics

Tunnel Length:	13,161	m
Finished Diameter:	7.5	m
Initial Support Type:	Not Applicable	
Initial Support Thickness:	0	m
Final Lining Thickness:	0.35	m
Grout Thickness:	0.1	m

Theoretical Excavation Volumes

Total Neat Excavation:	729,352	Cubic Metres
Initial Lining Volume:	0	Cubic Metres
Final Lining Volume:	113,599	Cubic Metres
Theoretical Grout Volume:	34,318	Cubic Metres

Normal Excavation/Support Cycle

Excavation Cycle Length:	1.5	Metres
Excavate:	24	Minutes
Erect Support:	27	Minutes
Extend Services:	0	Minutes
Total Cycle Time:	51	Minutes

Difficult Excavation/Support Cycle

Length of Difficult Excavation:	1400	Metres
Excavate:	73	Minutes
Erect Support:	54	Minutes
Extend Services:	0	Minutes
Total Cycle Time:	127	Minutes

Reduction Factors

Machine availability:	80	%
Back up efficiency:	55	%
Planned maintenance:	5	%
Learning curve efficiency:	40	%
Learning curve duration time:	8	Weeks

Learning Curve Rate:	7.1	m/day
Experienced Advance Rate:	17.7	m/day
Difficult Advance Rate:	7.1	m/day

TBM Skidding Through Excavation

Duration of skidding:	0	Weeks
Length of skidding:	0	Metres

Advance Rate and Shift Details

Shift Arrangement:	3 - 8 hour shifts x 7 days per week	
Avg. Drive Advance per Shift:	4.90	Metres
Avg. Drive Advance per Day:	15	Metres
Avg. Drive Advance per Week:	103	Metres
Duration of Tunneling (Incl. Skid):	127.84	Weeks
Total number of shifts (Incl. Skid):	2,685	

	Metres	Days
Learning Curve Drive:	397	56
Experienced Drive:	11,364	642
Difficult Drive:	1,400	197
Skidding Portion:	0	0

Estimate Definition ID: 2737

Estimated by: ____________________

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Checked by: ____________________

	Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor						
	Pit boss	52.29	$/hr	21,481.00	1.00	1,123,241
	Working foreman	52.29	$/hr	21,481.00	2.00	2,246,483
	Tunnel miner	48.89	$/hr	21,481.00	3.00	3,150,618
	Tunnel laborer	48.44	$/hr	21,481.00	4.00	4,162,159
	Loco driver	49.34	$/hr	21,481.00	3.00	3,179,618
	Shaft bottom	48.44	$/hr	21,481.00	1.00	1,040,540
	TBM operator	49.34	$/hr	21,481.00	1.00	1,059,873
	Tunnel fitter	49.34	$/hr	21,481.00	1.00	1,059,873
	Tunnel electrician	49.34	$/hr	21,481.00	1.00	1,059,873
	Shaft top	47.99	$/hr	21,481.00	2.00	2,061,746
	Crane operator	49.34	$/hr	21,481.00	1.00	1,059,873
	Surface laborer	47.99	$/hr	21,481.00	4.00	4,123,493
	Equipment laborer	48.44	$/hr	21,481.00	4.00	4,162,159
					28.00	$29,489,546
Plant						
	TBM	300,000.00	$/m2	55.42	0.80	13,300,800
	TBM backup	1,430,000.00	$/Nr	1.00	1.00	1,430,000
	Loco	5,000.00	$/wk	127.84	3.00	1,917,600
	Muck cars & grout cars	1,900.00	$/wk	127.84	21.00	5,100,816
	Flat cars	310.00	$/wk	127.84	6.00	237,782
	Manriders	310.00	$/wk	127.84	2.00	79,261
	Track	130.00	$/m	13,161.00	1.00	1,710,930
	Air pipe	30.00	$/m	13,161.00	1.00	394,830
	Water pipe	25.00	$/m	13,161.00	1.00	329,025
	Pump main	50.00	$/m	13,161.00	1.00	658,050
	Cabling	80.00	$/m	13,161.00	1.00	1,052,880
	Lighting	30.00	$/m	13,161.00	1.00	394,830
	Vent ducting	30.00	$/m	13,161.00	1.00	394,830
	Grout mixers	7,100.00	$/wk	127.84	1.00	907,664
	Grout pumps	3,400.00	$/wk	127.84	1.00	434,656
	Grout hoses & pipes	196.00	$/wk	127.84	2.00	50,113
	Transformers & switchgear - LV	750.00	$/wk	127.84	2.00	191,760
	Small tools	2,600.00	$/wk	127.84	1.00	332,384
	Shaft crane	9,000.00	$/wk	127.84	1.00	1,150,560
	Compressors	950.00	$/wk	127.84	1.00	121,448
	Low pressure C/A system	3,800.00	$/wk	127.84	1.00	485,792
	Pipework and controls	655.00	$/wk	127.84	2.00	167,470
	Generators	2,000.00	$/wk	127.84	1.00	255,680
	Transformers & switchgear - HV	5,200.00	$/wk	127.84	1.00	664,768
	Surface fans	800.00	$/wk	127.84	2.00	204,544
	Loaders	2,300.00	$/wk	127.84	2.00	588,064
	Other surface plant	2,600.00	$/wk	127.84	1.00	332,384

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Tunnel C/A system	40,000.00	$/wk	127.84	1.00	5,113,600
					$38,002,522
Consumables					
Electrical power	0.18	$/kwh	21,481.00	3,000.00	11,599,740
Gas oil	0.45	$/L	48,000.00	1.00	21,600
Lubrication materials	90.00	$/wk	127.84	1.00	11,506
TBM spares, cutters	250.00	$/m	13,161.00	1.00	3,290,250
Filters etc.	300.00	$/wk	127.84	1.00	38,352
Hydraulic oil	0.90	$/L	32,000.00	1.00	28,800
Other consumables	160.00	$/wk	127.84	1.00	20,454
Tail seal grease	100.00	$/m	13,161.00	1.00	1,316,100
					$16,326,802
Materials					
Concrete lining rings	8,300.31	$/Nr	8,774.00	1.00	72,826,912
Gaskets	130.00	$/m	13,161.00	1.00	1,710,930
Bolts	12.00	$/Nr	1,765.00	30.00	635,400
Grout	145.00	$/m3	34,318.00	1.00	4,976,110
Grout plugs	0.50	$/Nr	1,765.00	7.00	6,178
Packers	10.00	$/Nr	3,633.00	12.00	435,960
Temporary materials	2,250.00	$/wk	127.84	1.00	287,640
Other materials	0.00	$/t	0.00	1.00	0
					$80,879,129
Subcontracts					
Soil disposal	20.00	$/m3	729,352.00	1.50	21,880,560
					$21,880,560

Total Estimated Cost:	$186,578,560
Total Estimated Cost per Metre:	$14,177
Total Estimated Cost per Week:	$1,459,508
Total Estimated Cost per Shift:	$69,487

Estimate Definition ID: 2737

Estimated by: ____________

Checked by: ____________

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Tunnel Estimating Database

Detailed Cost Estimate Report

Version 2.6

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Project:	Newfoundland Fixed Link Pre-feasibility Study	**Project Number:**	213789
Estimate Description:	Maintain TBM	**Parent Estimate ID:**	2638
Tunnel Name:	Rail Bored 2 TBM	**Project Phase:**	Conceptual
Construction Activity:	TBM Maintenance	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	August 17, 2004
Estimate Definition ID:	2729	**Tunnel Characteristics ID:**	879

Tunnel Characteristics

Finished Diameter: 7.5 m

Activity Details

Shift Arrangement 1 - 6 hour shifts x 1 days per week

Duration of Activity 127 Weeks

Total Number of Shifts 127

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor					
Working foreman	52.29	$/hr	762.00	1.50	59,767
Loco driver	49.34	$/hr	762.00	1.50	56,396
Shaft bottom	48.44	$/hr	762.00	1.50	55,367
TBM operator	49.34	$/hr	762.00	1.50	56,396
Tunnel fitter	49.34	$/hr	762.00	1.50	56,396
Tunnel electrician	49.34	$/hr	762.00	1.50	56,396
Shaft top	47.99	$/hr	762.00	1.50	54,853
Surface laborer	47.99	$/hr	762.00	1.50	54,853
				12.00	$450,422
Consumables					
Electrical power	0.10	$/kwh	762.00	600.00	45,720
Gas oil	0.45	$/L	0.00	1.00	0
Other consumables	0.00	$/wk	127.00	1.00	0
					$45,720
Materials					
Temporary materials	200.00	$/wk	127.00	1.00	25,400
Other materials	0.00	$/t	0.00	1.00	0
					$25,400

Total Estimated Cost: $521,542

Estimate Definition ID: 2729

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Tunnel Estimating Database

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Detailed Cost Estimate Report

Project:	Newfoundland Fixed Link Pre-feasibility Study	**Project Number:**	213789
Estimate Description:	Clean tunnel	**Parent Estimate ID:**	1562
Tunnel Name:	Single Rail Bored	**Project Phase:**	Conceptual
Construction Activity:	Tunnel Clean Up	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	May 21, 2004
Estimate Definition ID:	2639	**Tunnel Characteristics ID:**	843

Tunnel Characteristics

Tunnel Length:	26,322	m	
Finished Diameter:	7.5	m	(Circular Tunnels)
Excavated Cross Section:	0	m2	(Non-circular Tunnels)
Excavated Perimeter:	0	m	(Non-circular Tunnels)

Productivity Cycle

Section Length	30	Metres
Vent Line Removal Time	120	Minutes
Track Removal Time	60	Minutes
Temp Lighting Removal Time	60	Minutes
Clean Up Time	120	Minutes
Total Cycle Time	360	Minutes

Reduction Factors

Learning Curve Efficiency:	50	%
Back Up Efficiency:	80	%
Learning Curve Duration:	1	Weeks

Shift Details

Shift Arrangement:	3 - 8 hour shifts x 7 days per week	
Avg. Advance per Shift:	31.58	Metres
Avg. Advance per Week:	664	Metres
Total number of hours:	6,669	

Clean Up Productivity Data

	Average Advance		Drive Length		Drive Duration					
Learning Curve Portion:	48.0	m/day	336	Metres	21	Shifts	7	Days	1.00	Weeks
Experienced Drive Portion:	96.0	m/day	25,986	Metres	812	Shifts	271	Days	38.67	Weeks
Total:	94.8	m/day	26,322	Metres	834	Shifts	278	Days	39.67	Weeks

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor					
Tunnel laborer	48.44	$/hr	6,668.00	6.00	1,937,988
Shaft bottom	48.44	$/hr	6,668.00	1.00	322,998
Shaft top	47.99	$/hr	6,668.00	1.00	319,997
Crane operator	49.34	$/hr	6,668.00	1.00	328,999
				9.00	$2,909,982
Plant					
Transformers & switchgear - LV	750.00	$/wk	39.67	1.00	29,753

Estimate Definition ID: 2639

Estimated by: ____________________

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Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Man hoists	2,600.00	$/wk	39.67	1.00	103,142
Shaft crane	9,000.00	$/wk	39.67	1.00	357,030
Compressors	950.00	$/wk	39.67	1.00	37,687
Loaders	2,260.00	$/wk	39.67	1.00	89,654
Other surface plant	2,600.00	$/wk	39.67	1.00	103,142
Bobcat	500.00	$/wk	39.67	1.00	19,835
					$740,242
Consumables					
Electrical power	0.10	$/kwh	6,668.00	200.00	133,360
					$133,360

Total Estimated Cost:	$3,783,584
Total Estimated Cost per Metre:	$144
Total Estimated Cost per Week:	$95,377
Total Estimated Cost per Shift:	$4,539

Estimate Definition ID: 2639

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Tunnel Estimating Database

Detailed Cost Estimate Report

Version 2.6

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Project:	Newfoundland Fixed Link Pre-feasibility Study	**Project Number:**	213789
Estimate Description:	Remove TBM	**Parent Estimate ID:**	1564
Tunnel Name:	Single Rail Bored	**Project Phase:**	Conceptual
Construction Activity:	TBM Removal	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	May 21, 2004
Estimate Definition ID:	2640	**Tunnel Characteristics ID:**	843

Tunnel Characteristics

Finished Diameter: 7.5 m

Activity Details

Shift Arrangement	3 - 8 hour shifts x 7 days per week
Duration of Activity	2.2 Weeks
Total Number of Shifts	46.2

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor					
Pit boss	52.29	$/hr	370.00	1.00	19,347
Tunnel miner	48.89	$/hr	370.00	3.00	54,268
Shaft bottom	48.44	$/hr	370.00	2.00	35,846
Tunnel fitter	49.34	$/hr	370.00	1.00	18,256
Tunnel electrician	49.34	$/hr	370.00	1.00	18,256
Shaft top	47.99	$/hr	370.00	2.00	35,513
Crane operator	49.34	$/hr	370.00	2.00	36,512
Surface laborer	47.99	$/hr	370.00	2.00	35,513
Equipment laborer	48.44	$/hr	370.00	1.00	17,923
				15.00	$271,432
Plant					
Loco	5,000.00	$/wk	2.20	1.00	11,000
Muck cars & grout cars	1,900.00	$/wk	2.20	6.00	25,080
Flat cars	310.00	$/wk	2.20	4.00	2,728
Manriders	310.00	$/wk	2.20	1.00	682
Booster fans	800.00	$/wk	2.20	1.00	1,760
Transformers & switchgear - LV	750.00	$/wk	2.20	1.00	1,650
Other plant	1,400.00	$/wk	2.20	1.00	3,080
Man hoists	2,000.00	$/wk	2.20	1.00	4,400
Shaft crane	9,000.00	$/wk	2.20	1.00	19,800
50T Crane	3,000.00	$/wk	2.20	1.00	6,600
TBM Crane	15,000.00	$/wk	2.20	1.00	33,000
Compressors	950.00	$/wk	2.20	1.00	2,090
Transformers & switchgear - HV	5,200.00	$/wk	2.20	1.00	11,440
Surface fans	800.00	$/wk	2.20	1.00	1,760
					$125,070

Estimated by: ____________

Checked by: ____________

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Consumables					
Electrical power	0.00	$/kwh	370.00	600.00	0
Gas oil	0.40	$/L	15.00	1,000.00	6,000
Lubrication materials	0.00	$/wk	2.20	1.00	0
Filters etc.	0.00	$/wk	2.20	1.00	0
Hydraulic oil	0.00	$/L	0.00	1.00	0
Other consumables	500.00	$/wk	2.20	1.00	1,100
					$7,100
Materials					
Temporary materials	500.00	$/wk	2.20	1.00	1,100
Thrust frame	0.00	$/wk	2.20	1.00	0
					$1,100
General Supplies					
Small tools	700.00	$/wk	2.20	1.00	1,540
					$1,540
			Total Estimated Cost:		$406,242

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Tunnel Estimating Database

Detailed Cost Estimate Report

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Project:	NFLink	**Project Number:**	213789
Estimate Description:	Liner production	**Parent Estimate ID:**	1596
Tunnel Name:	Single Rail Bored	**Project Phase:**	Conceptual
Construction Activity:	Precast Linings	**Geology Type:**	Not Applicable
Tunnel Technique:	EPB TBM - Precast segmental	**Estimate Date:**	June 01, 2004
Estimate Definition ID:	2642	**Tunnel Characteristics ID:**	843

Tunnel Characteristics

Tunnel Length:	26,322	m
Finished Diameter:	7.5	m
Final Lining Thickness:	0.35	m

Assumptions

A) Duration

	Maximum	Minimum	
TBM Fabrication Time	19	15	Months
TBM Erection Time	3	2	Months
Tunneling Time	86	81	Months
Total	**108**	**98**	Months
Facility Setup Time	6	5	Months
Learning Curve/Shakedown Time	1	1	Months
Concrete Strength Gain Time	1	1	Months
Available Manufacturing Time	**100**	**91**	Months

B) Production

Allowance for Damage	2	%
Ring Length	1.5	m
Number of Rings Required	17,899	
Production Rate Required	49.2	Rings/Week
Actual Production Rate Achieved	50	Rings/Week

Investment on plant, equipment and moulds $5,000,000

Initial Shakedown Time	4	Weeks
Production Time	358.0	Weeks

	Shakedown Crew	Production / QC Crew
Shifts per Day	1	2
Hours per Shift	12	12
Days per Week	5	5

Estimate Definition ID: 2642

Estimated by: ____________________

Checked by: ____________________

Number of Rings per Truck	1
Concrete	12.95 m3/ring
Reinforcing Steel	120 kg/m3
Dunnage Assumption	50 % of total required storage

C) Overheads

	$/Month	Months	Cost	
Project Manager Rate	7,000	97	679,000	
Plant Manager Rate	5,000	95	475,000	
Quality Manager Rate	5,000	93	465,000	
Secretary Rate	2,000	97	194,000	
Office Building Cost			150,000	
Office Equipment and Supplies Cost			0	
Finance Assume $	1,000,000	97	485,000	
Financing @	6 %			
Head Office Support @	1 %		1,286,778	
Total Overhead Cost				$3,734,778
Profit Margin			10 %	

Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Labor					
Shakedown crew	25.00	$/hr	240.00	30.00	180,000
Production & QC crew	32.00	$/hr	42,958.00	30.00	41,239,680
				60.00	$41,419,680
Consumables					
Power	0.06	$/kwh	43,198.00	1,020.00	2,643,718
Heating	0.11	$/m2/wk	362.00	10,600.00	422,092
Steam curing	0.54	$/m2/wk	362.00	2,000.00	390,960
Fuel	0.50	$/L	362.00	3,000.00	543,000
Water	0.05	$/L	231,743.00	100.00	1,158,715
					$5,158,485
Materials					
Concrete	84.00	$/m3	12.95	17,899.00	19,470,532
Rebar	1.00	$/kg	1,554.00	17,899.00	27,815,046
Grout nozzles	3.00	$/Nr	17,899.00	12.00	644,364
Lifting socket	10.00	$/Nr	17,899.00	12.00	2,147,880
Bolt inserts	5.00	$/Nr	17,899.00	12.00	1,073,940
Gaskets	100.00	$/Nr	17,899.00	12.00	21,478,800
Dunnage	2.50	$/m	18.00	8,949.00	402,705
Site preparation	10.00	$/m2	12.32	8,949.00	1,102,517
					$74,135,784

Estimate Definition ID: 2642

Estimated by: ____________________

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Resource Name	Unit Rate	UOM	Unit Quantity	Resource Quantity	Total
Subcontracts					
Delivery	80.00	$/hr	2.00	17,899.00	2,863,840
Testing	100,000.00	$/Nr	1.00	1.00	100,000
					$2,963,840

Subtotal:	$123,677,789
Investment on Plant:	$5,000,000
Total Overhead Cost:	$3,734,778
Subtotal:	$132,412,566
Profit:	$13,241,257
Total Precast Lining Cost:	**$145,653,823**
Total Cost per Cubic Metre:	**$629**
Total Cost per Ring:	**$8,138**

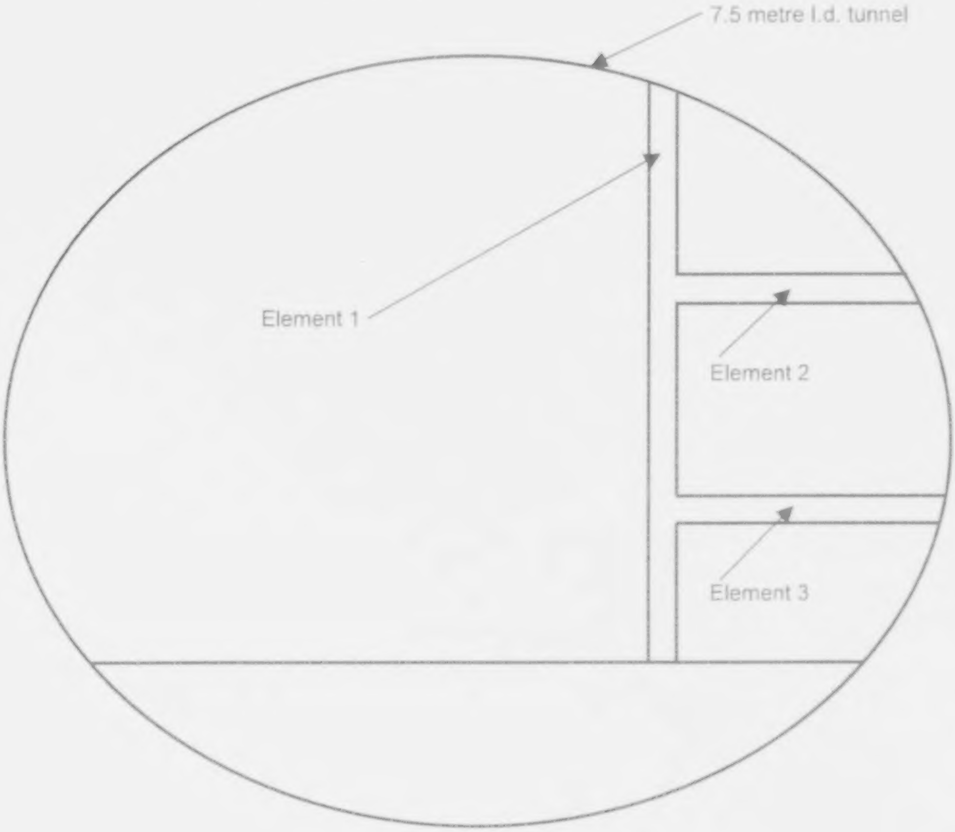
Estimated by: ____________________

Checked by: ____________________

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Bored Railway Tunnel
Tunnel Structural Finishes

Page 1 of 2
Date: June 07, 2004
Calculation by: A.White

Tunnel length= 26320 m


7.5 metre I.d. tunnel
Element 1
Element 2
Element 3

Assumed tunnel cross section

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Bored Railway Tunnel
Tunnel Structural Finishes

Date: June 07, 2004
Calculation by: A.White

Quantity Take-off

Concrete

Element	Nr.	L(m)	b(m)	d(m)	Concrete Qty(m3)	Rebar Qty(m3)
1	1	26320	0.3	5.9	46586	5590.4
2	1	26320	1.2	0.3	9475.2	1137.0
3	1	26320	1.2	0.3	9475.2	1137.0
					65537 m3	6727 t

Formwork/falsework

Element	Nr.	L(m)	d(m)	Faces	Area(m2)
1	1	26320	5.9	2	310576
2	1	26320	1.2	1	31584
3	1	26320	1.2	1	31584
					373744 m2

Rates

Concrete	m3	190
Formwork	m2	140
Reinforcement	t	1600

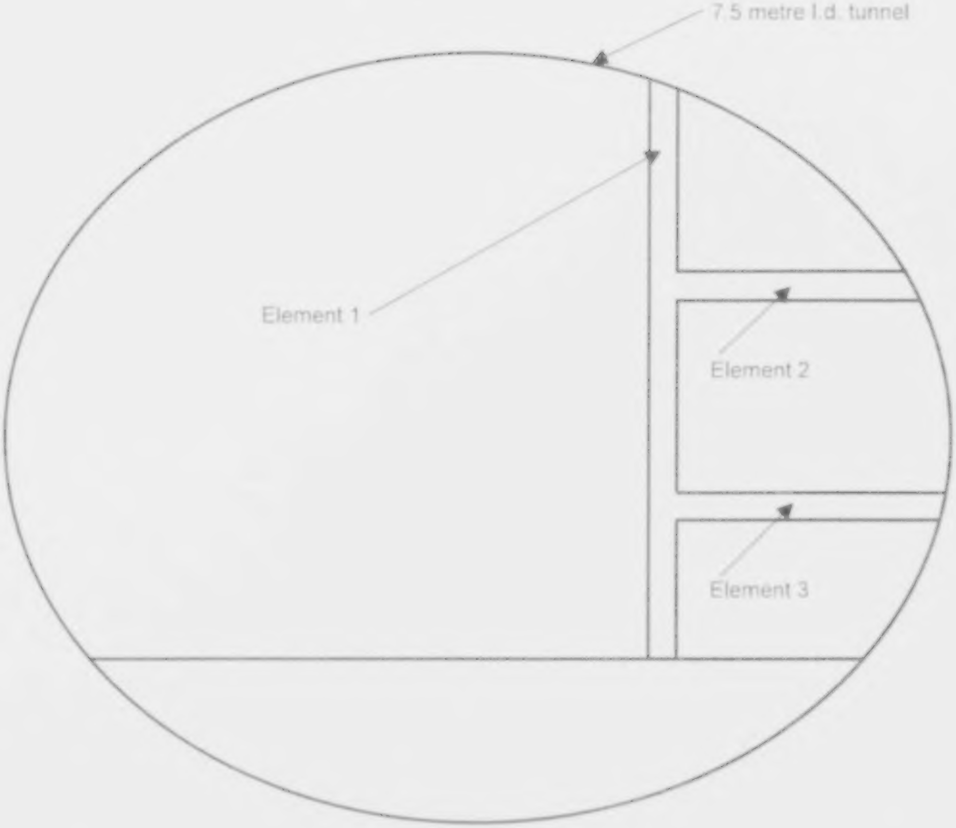
Costs

Concrete	m3	65537	m3	at	190	=	12,451,992
Formwork	m2	373744	m2	at	140	=	52,324,160
Reinforcement	t	6727	t	at	1600	=	10,763,827
						$	75,539,979

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Bored Railway Tunnel
Tunnel Structural Finishes

Page 1 of 2
Date: June 07, 2004
Calculation by: A.White

Tunnel length= 26320 m


7.5 metre I.d. tunnel
Element 1
Element 2
Element 3

Assumed tunnel cross section

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Single Bored Railway Tunnel
Tunnel Structural Finishes

Page 2 of 2
Date: June 07, 2004
Calculation by: A White

Quantity Take-off

Concrete

Element	Nr.	L(m)	b(m)	d(m)	Concrete Qty(m3)		Rebar Qty(m3)	
1	1	26320	0.3	5.9	46586		5590.4	
2	1	26320	1.2	0.3	9475.2		1137.0	
3	1	26320	1.2	0.3	9475.2		1137.0	
					65537	m3	6727	t

Formwork/falsework

Element	Nr.	L(m)	d(m)	Faces	Area(m2)	
1	1	26320	5.9	2	310576	
2	1	26320	1.2	1	31584	
3	1	26320	1.2	1	31584	
					373744	m2

Rates

Concrete	m3	190
Formwork	m2	140
Reinforcement	t	1600

Costs

Concrete	m3	65537	m3	at	190	=	12,451,992
Formwork	m2	373744	m2	at	140	=	52,324,160
Reinforcement	t	6727	t	at	1600	=	10,763,827
						$	75,539,979

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: North Approach
Option: Bored Rail Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient	-0.08	%	+ sloping same way as track/road - sloping against track/road
Track/Road Gradient	1.663	%	
Ground elevation at portal	100	m	
Bottom of slab elevation at portal	86.95	m	
Total length=	748.7091	m	
Total Cost=$	7.8	M	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel

UNIT RATES

Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: North Approach
Option: Bored Rail Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient -0.08 %
+ sloping same way as track/road
- sloping against track/road

Track/Road Gradient 1.663 %

Ground elevation at portal 100 m

Bottom of slab elevation at portal 86.95 m

Total length= 748.7091 m

Total Cost=$ 7.8 M

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel

UNIT RATES

Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
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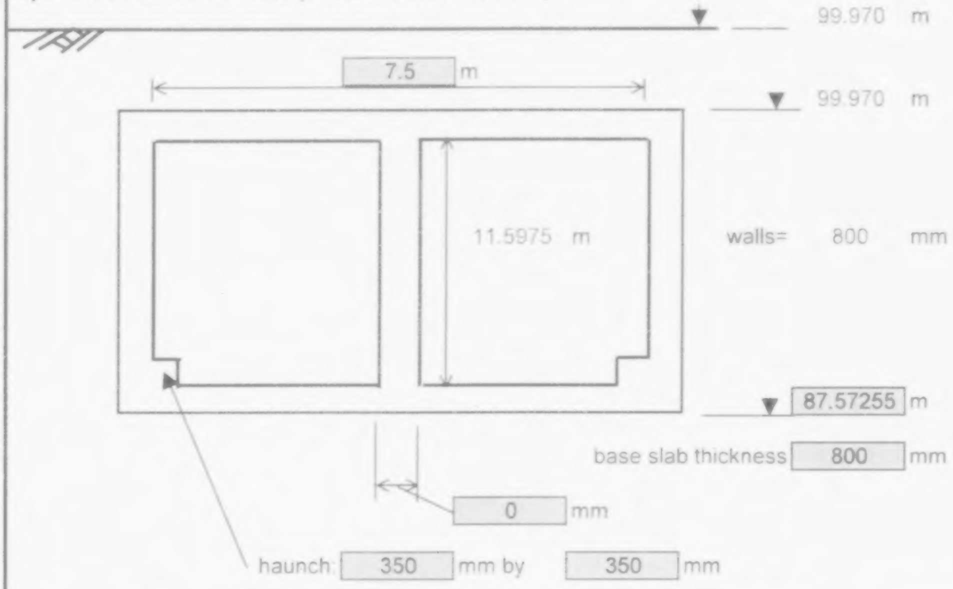
Section Cut and Cover
Length of section: 74.87091 m **Section** 1

Input cross-section details (cut and cover solution)



99.970 m
7.5 m
99.970 m
11.5975 m
walls= 800 mm
87.57255 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	8446.7	m3	
concrete=	1952.708	m3	
rebar=	234.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1736.631	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1856.4	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	681.3253	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	8446.7	60	506803.8
concrete	m3	1952.708	190.0	371014.6
rebar	tonnes	234.3	1600	374920
formwork/falsework	m2	1736.631	140	243128.3
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	1856.4	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	681.3253	30	20439.76
			Total	1516306

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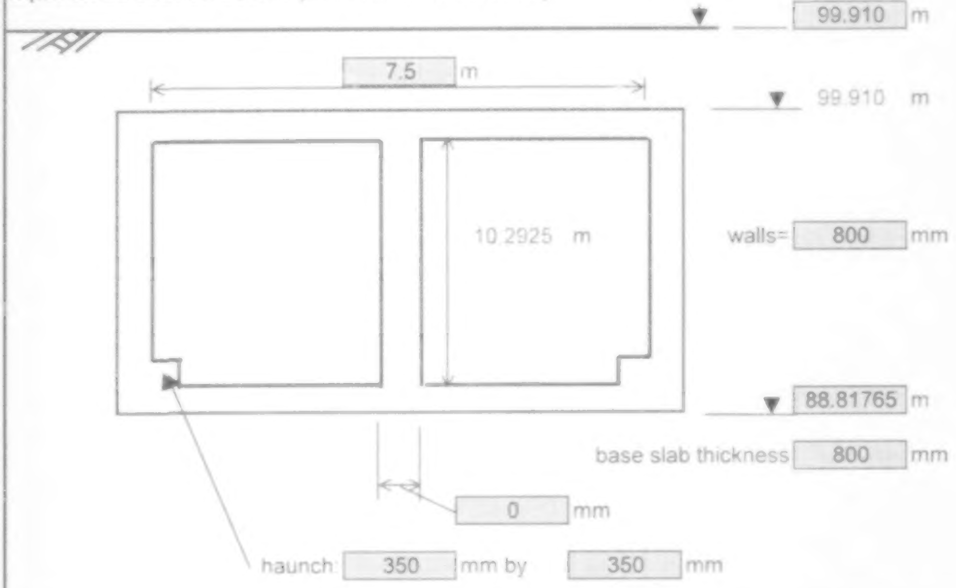
Section Cut and Cover
Length of section: 74.87091 m **Section** 2

Input cross-section details (cut and cover solution)



99.910 m
7.5 m
99.910 m
10.2925 m
walls= 800 mm
88.81765 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	7557.6	m3	
concrete=	1796.378	m3	
rebar=	215.6	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1541.218	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1661.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	681.3253	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	7557.6	60	453456.1
concrete	m3	1796.378	190.0	341311.8
rebar	tonnes	215.6	1600	344904.5
formwork/falsework	m2	1541.218	140	215770.5
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	1661.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	681.3253	30	20439.76
			Total	1375883

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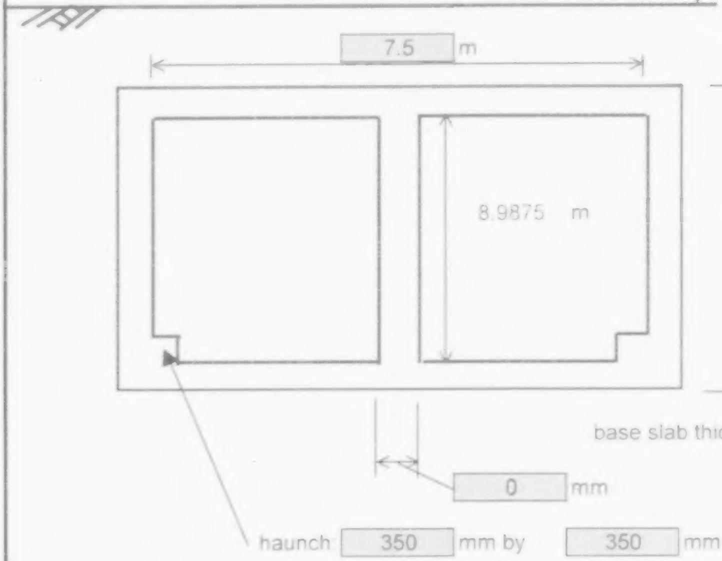
Section Cut and Cover
Length of section: 74.87091 m
Section 3

Input cross-section details (cut and cover solution)

99.850 m



7.5 m
99.850 m
8.9875 m
walls= 698.125 mm
90.06276 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	6519.2	m3	
concrete=	1490.74	m3	
rebar=	178.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1345.805	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1465.6	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	666.0704	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	6519.2	60	391149.8
concrete	m3	1490.74	190.0	283240.5
rebar	tonnes	178.9	1600	286222
formwork/falsework	m2	1345.805	140	188412.7
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1465.6	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	666.0704	30	19982.11
			Total	1169007

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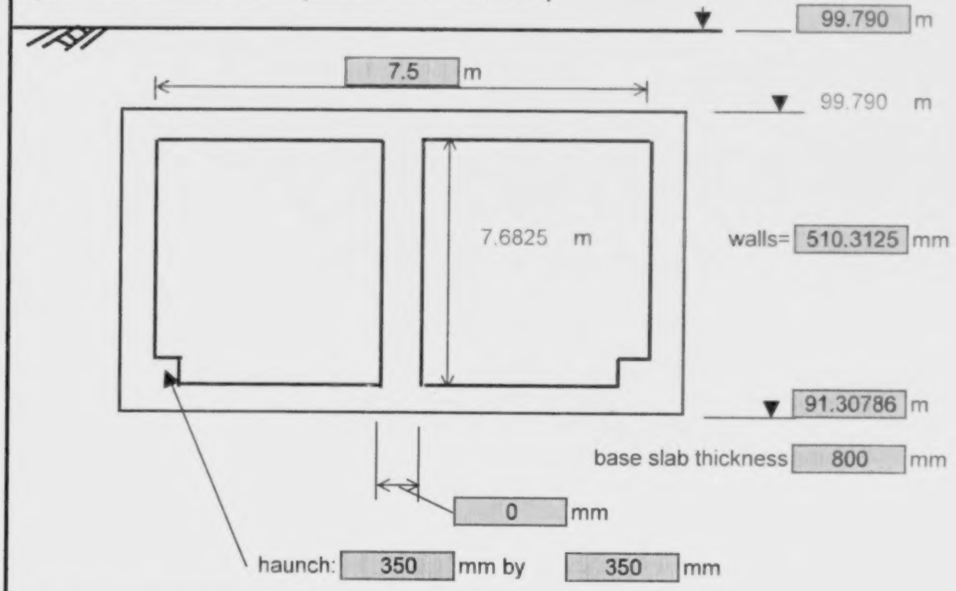
Section Cut and Cover
Length of section: 74.87091 m **Section 4**

Input cross-section details (cut and cover solution)


99.790 m
7.5 m
99.790 m
7.6825 m
walls= 510.3125 mm
91.30786 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	5411.4	m3	
concrete=	1115.76	m3	
rebar=	133.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1150.392	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1270.2	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	637.947	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	5411.4	60	324683.1
concrete	m3	1115.76	190.0	211994.4
rebar	tonnes	133.9	1600	214225.9
formwork/falsework	m2	1150.392	140	161054.8
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1270.2	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	637.947	30	19138.41
			Total	931096.7

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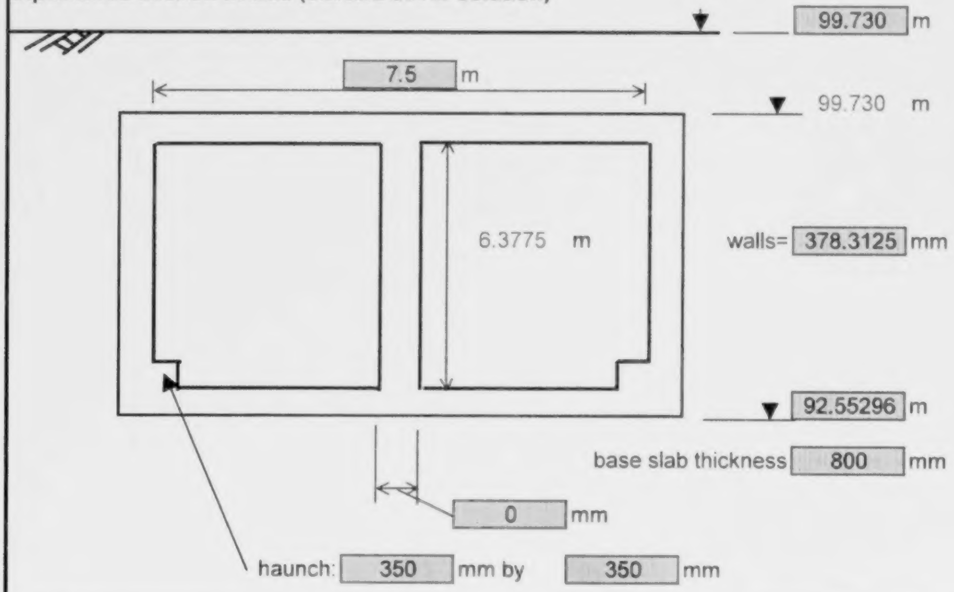
Section Cut and Cover
Length of section: 74.87091 m **Section** 5

Input cross-section details (cut and cover solution)



99.730 m
7.5 m
99.730 m
6.3775 m
walls= 378.3125 mm
92.55296 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	4437.0	m3	
concrete=	874.1685	m3	
rebar=	104.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	954.9785	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1074.8	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	618.181	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	4437.0	60	266219.7
concrete	m3	874.1685	190.0	166092
rebar	tonnes	104.9	1600	167840.4
formwork/falsework	m2	954.9785	140	133697
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1074.8	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	618.181	30	18545.43
			Total	752394.5

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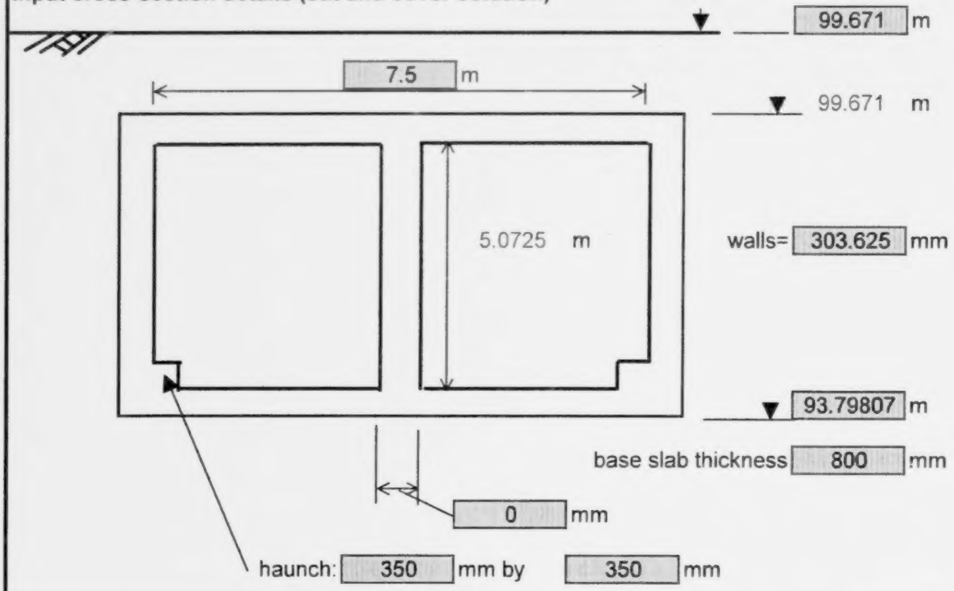
Section Cut and Cover
Length of section: 74.87091 m
Section 6

Input cross-section details (cut and cover solution)



walls= 303.625 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	3564.6	m3	
concrete=	734.5642	m3	
rebar=	88.1	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	759.5654	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	879.4	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	606.9972	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	3564.6	60	213875.5
concrete	m3	734.5642	190.0	139567.2
rebar	tonnes	88.1	1600	141036.3
formwork/falsework	m2	759.5654	140	106339.2
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	879.4	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	606.9972	30	18209.92
			Total	619028.1

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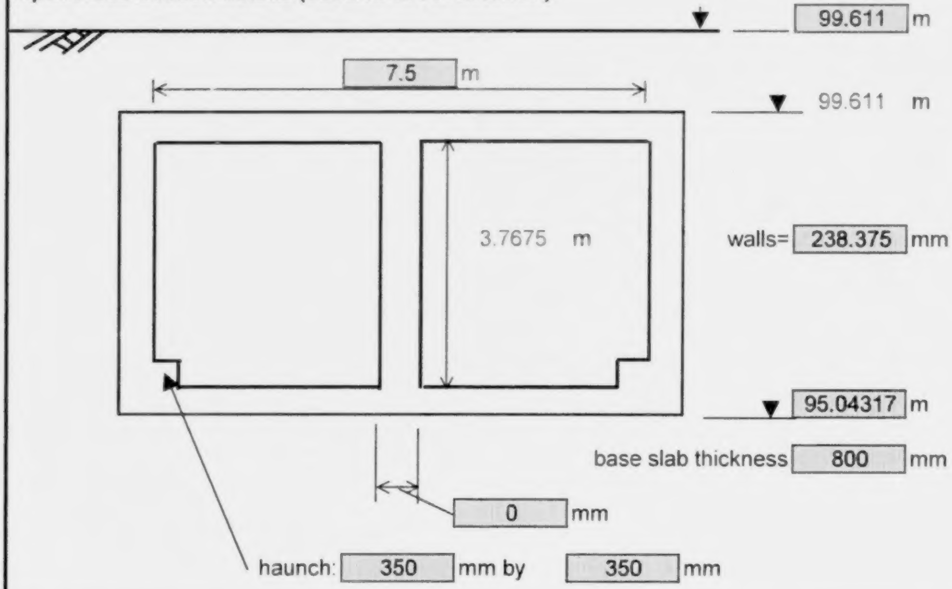
Section Cut and Cover
Length of section: 74.87091 m **Section** 7

Input cross-section details (cut and cover solution)



99.611 m
7.5 m
99.611 m
3.7675 m
walls= 238.375 mm
95.04317 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	2727.8	m3	
concrete=	630.6044	m3	
rebar=	75.7	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	564.1523	m2	
SP&L<=4.6m deep	683.9	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	597.2265	m2	

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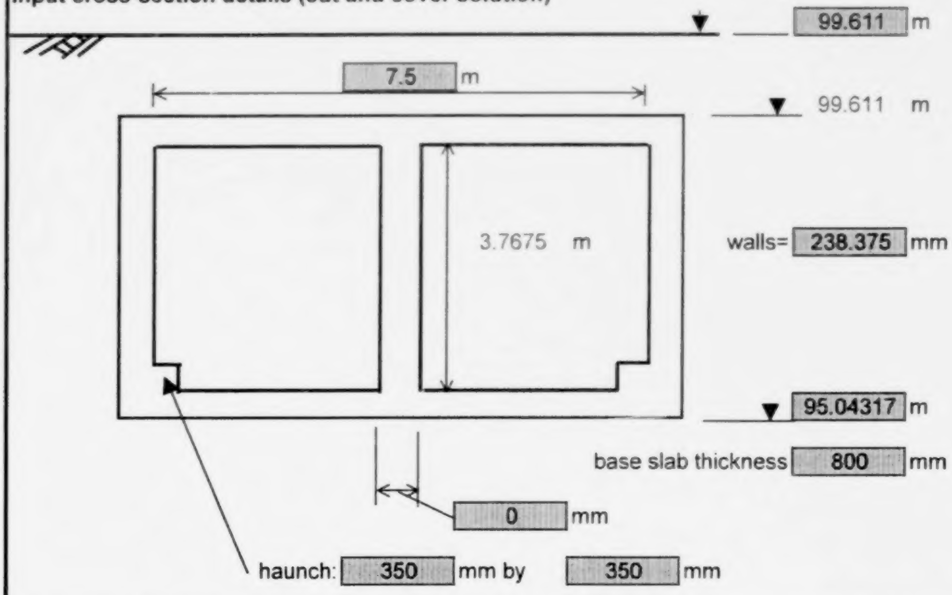
Section Cut and Cover
Length of section: 74.87091 m
Section 7

Input cross-section details (cut and cover solution)



99.611 m
7.5 m
99.611 m
3.7675 m
walls= 238.375 mm
95.04317 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	2727.8	m3	
concrete=	630.6044	m3	
rebar=	75.7	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	564.1523	m2	
SP&L<=4.6m deep	683.9	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	597.2265	m2	

Newfoundland Fixed Link Pre-feasibility Study
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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	2727.8	60	163669.9
concrete	m3	630.6044	190.0	119814.8
rebar	tonnes	75.7	1600	121076
formwork/falsework	m2	564.1523	140	78981.33
SP&L<=4.6m deep	m2	683.9	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	597.2265	30	17916.8
			Total	501458.9

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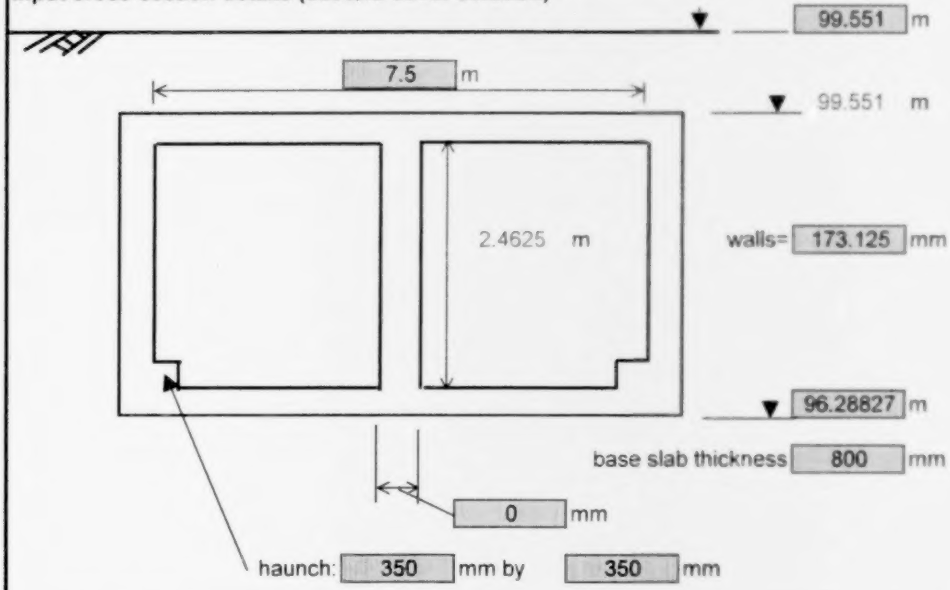
Section Cut and Cover
Length of section: 74.87091 m **Section** 8

Input cross-section details (cut and cover solution)



99.551 m
7.5 m
99.551 m
2.4625 m
walls= 173.125 mm
96.28827 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	1916.6	m3	
concrete=	552.1461	m3	
rebar=	66.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	368.7392	m2	
SP&L<=4.6m deep	488.5	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	587.4559	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	1916.6	60	114994.5
concrete	m3	552.1461	190.0	104907.8
rebar	tonnes	66.3	1600	106012
formwork/falsework	m2	368.7392	140	51623.49
SP&L<=4.6m deep	m2	488.5	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	587.4559	30	17623.68
			Total	395161.5

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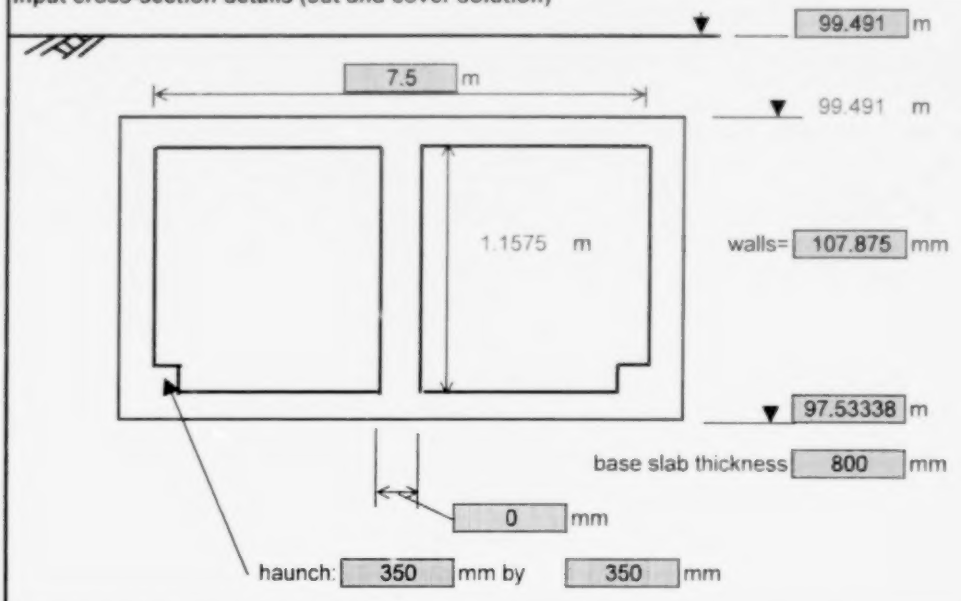
Section Cut and Cover
Length of section: 74.87091 m **Section** 9

Input cross-section details (cut and cover solution)



walls= 107.875 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	1130.8	m3	
concrete=	499.1891	m3	
rebar=	59.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	173.3262	m2	
SP&L<=4.6m deep	293.1	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	577.6852	m2	

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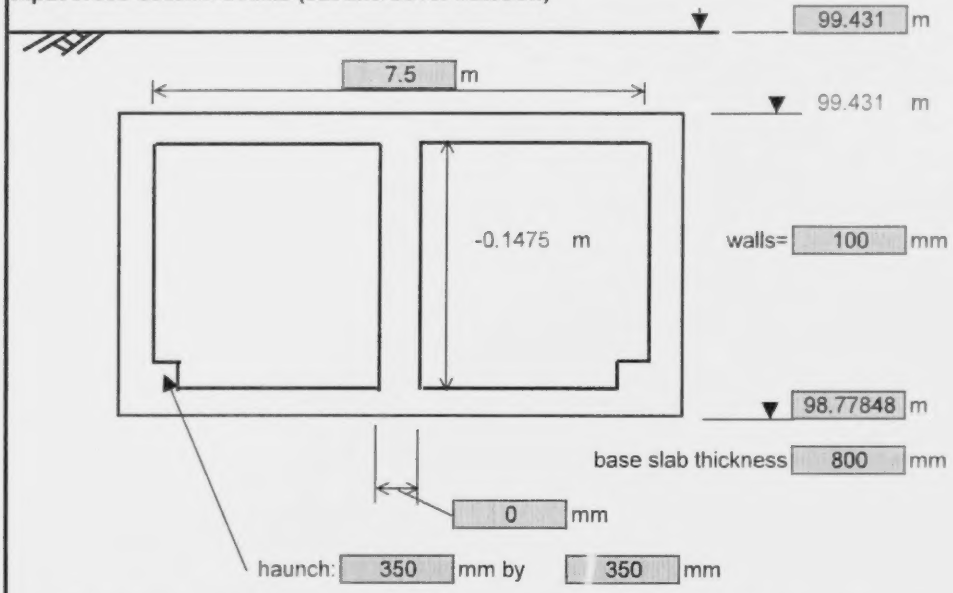
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	1130.8	60	67849.13
concrete	m3	499.1891	190.0	94845.93
rebar	tonnes	59.9	1600	95844.31
formwork/falsework	m2	173.3262	140	24265.66
SP&L<=4.6m deep	m2	293.1	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	577.6852	30	17330.56
			Total	300135.6

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
North Approach	**Calculations by:** ANW
Bored Rail Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 74.87091 m **Section** **10**

Input cross-section details (cut and cover solution)



99.431 m
7.5 m
99.431 m
-0.1475 m
walls= 100 mm
98.77848 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	376.2	m3	
concrete=	477.3395	m3	
rebar=	57.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	-22.08692	m2	
SP&L<=4.6m deep	97.7	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	576.506	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	376.2	60	22570.21
concrete	m3	477.3395	190.0	90694.51
rebar	tonnes	57.3	1600	91649.18
formwork/falsework	m2	-22.08692	140	-3092.169
SP&L<=4.6m deep	m2	97.7	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	576.506	30	17295.18
			Total	219116.9

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
Bored Rail Tunnel

Summary of Costs

Markup for adjacent 0 %

Section	**Cost**
1	1516306
2	1375883
3	1169007
4	931096.7
5	752394.5
6	619028.1
7	501458.9
8	395161.5
9	300135.6
10	219116.9
Sub-total	7779588

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: South Approach
Option: Bored Rail Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient 0 %
+ sloping same way as track/road
- sloping against track/road

Track/Road Gradient 1.663 %

Ground elevation at portal 100 m

Bottom of slab elevation at portal 86.95 m

Total length= 784.7264 m

Total Cost=$ 8.2 M

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel

UNIT RATES

Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: South Approach
Option: Bored Rail Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient 0 %

+ sloping same way as track/road
- sloping against track/road

Track/Road Gradient 1.663 %

Ground elevation at portal 100 m

Bottom of slab elevation at portal 86.95 m

Total length= 784.7264 m

Total Cost=$ 8.2 M

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel

UNIT RATES

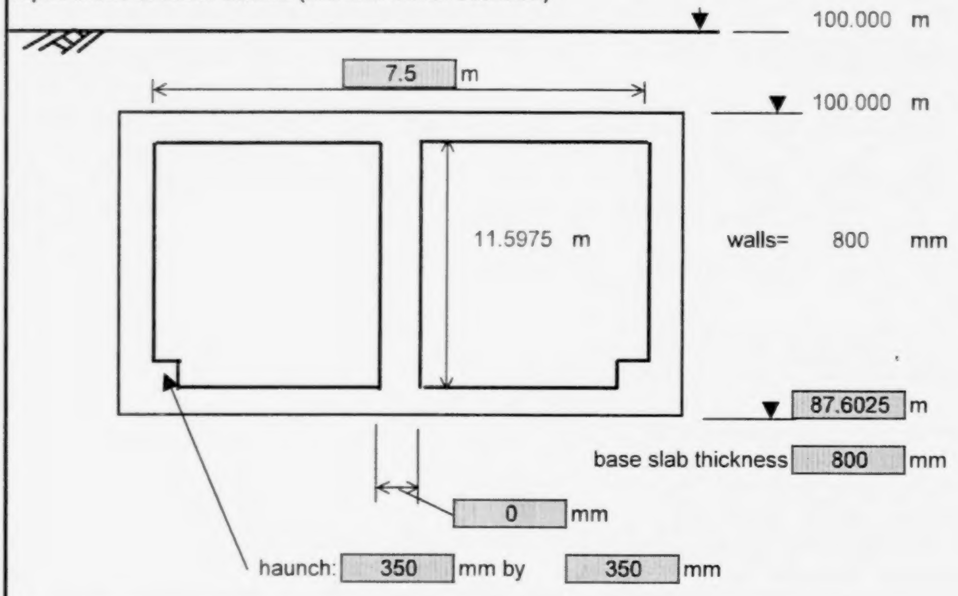
Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
Bored Rail Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section 1**

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
11.5975 m
walls= 800 mm
87.6025 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	8853.1	m3	
concrete=	2046.645	m3	
rebar=	245.6	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1820.173	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1945.7	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	714.101	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

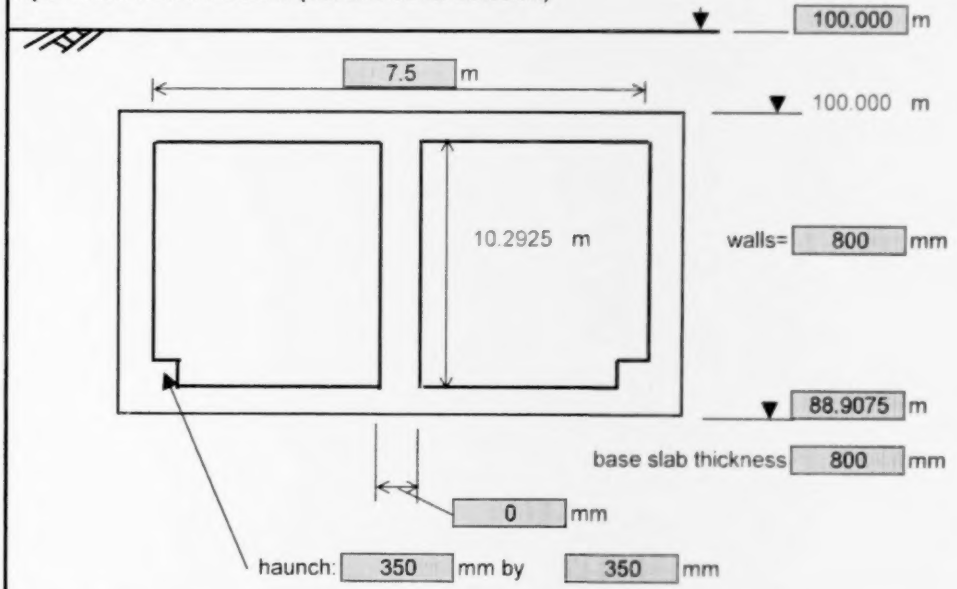
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	8853.1	60	531184
concrete	m3	2046.645	190.0	388862.5
rebar	tonnes	245.6	1600	392955.8
formwork/falsework	m2	1820.173	140	254824.2
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	1945.7	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	714.101	30	21423.03
			Total	1589250

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section 2**

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
10.2925 m
walls= 800 mm
88.9075 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation= 7921.2 m3
concrete= 1882.794 m3
rebar= 225.9 tonnes (assume 0.12t/m3 of concrete)
formwork/falsework= 1615.359 m2
SP&L<=4.6m deep 0.0 m2
4.6<SP&L<=6.7m deep 0.0 m2
6.7<SP&L<=10.6m deep 0.0 m2
10.6<SP&L<=13.7m deep 1740.9 m2
13.7<SP&L<=16.8m deep 0.0 m2
16.8<SP&L<=20.0m deep 0.0 m2
20<SP&L<=25m deep 0.0 m2
backfill= 0 m3
surface reinstatement= 714.101 m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

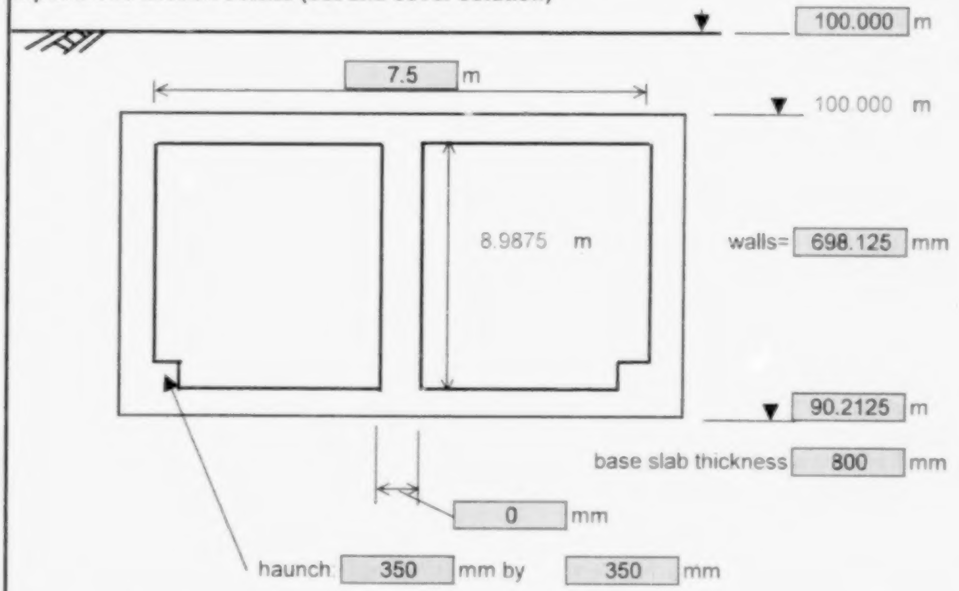
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	7921.2	60	475269.9
concrete	m3	1882.794	190.0	357730.9
rebar	tonnes	225.9	1600	361496.5
formwork/falsework	m2	1615.359	140	226150.3
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	1740.9	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	714.101	30	21423.03
			Total	1442071

Newfoundland Fixed Link Pre-feasibility Study Date: 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section 3**

Input cross-section details (cut and cover solution)



walls= 698.125 mm

base slab thickness 800 mm

haunch 350 mm by 350 mm

Calculated Quantities

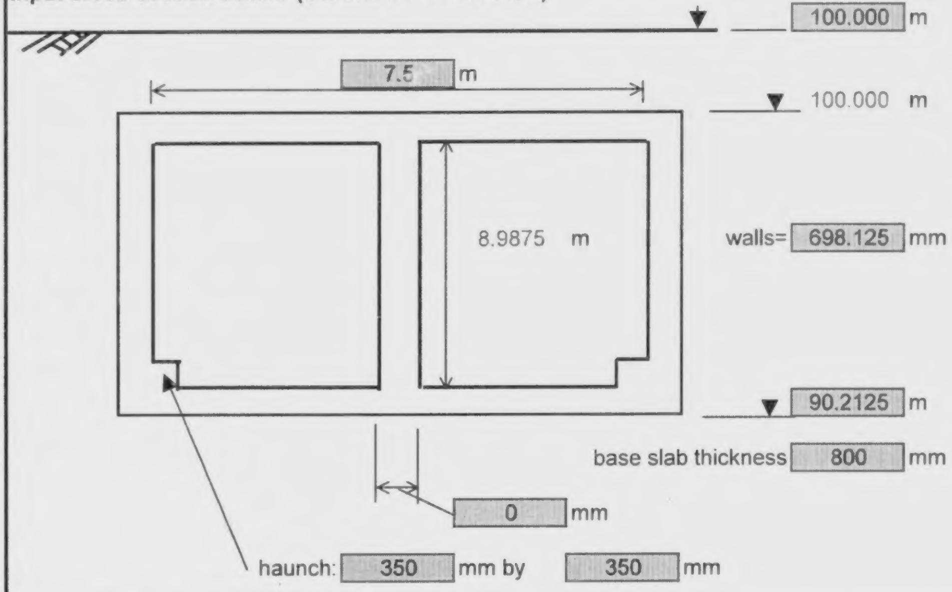
excavation=	6832.8	m3
concrete=	1562.453	m3
rebar=	187.5	tonnes (assume 0.12t/m3 of concrete)
formwork/falsework=	1410.546	m2
SP&L<=4.6m deep	0.0	m2
4.6<SP&L<=6.7m deep	0.0	m2
6.7<SP&L<=10.6m deep	1536.1	m2
10.6<SP&L<=13.7m deep	0.0	m2
13.7<SP&L<=16.8m deep	0.0	m2
16.8<SP&L<=20.0m deep	0.0	m2
20<SP&L<=25m deep	0.0	m2
backfill=	0	m3
surface reinstatement=	698.1122	m2

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 78.47264 m
Section 3

Input cross-section details (cut and cover solution)



walls= 698.125 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	6832.8	m3	
concrete=	1562.453	m3	
rebar=	187.5	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1410.546	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1536.1	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	698.1122	m2	

Newfoundland Fixed Link Pre-feasibility Study	Date: 8-Jun-04
South Approach	Calculations by: ANW
Bored Rail Tunnel	Page 2 of 2

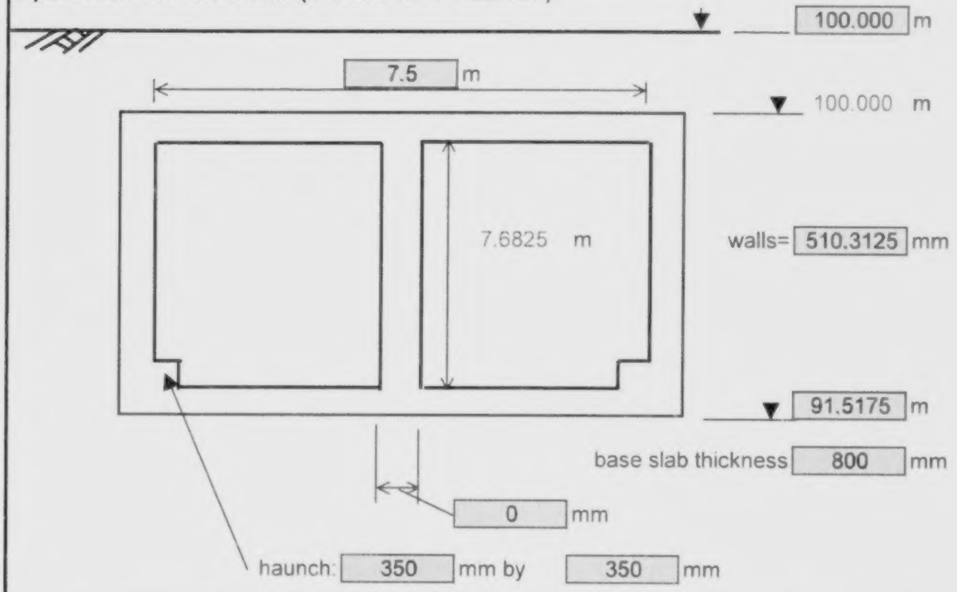
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	6832.8	60	409966.4
concrete	m3	1562.453	190.0	296866
rebar	tonnes	187.5	1600	299990.9
formwork/falsework	m2	1410.546	140	197476.4
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1536.1	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	698.1122	30	20943.37
			Total	1225243

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section 4**

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
7.6825 m
walls= 510.3125 mm
91.5175 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

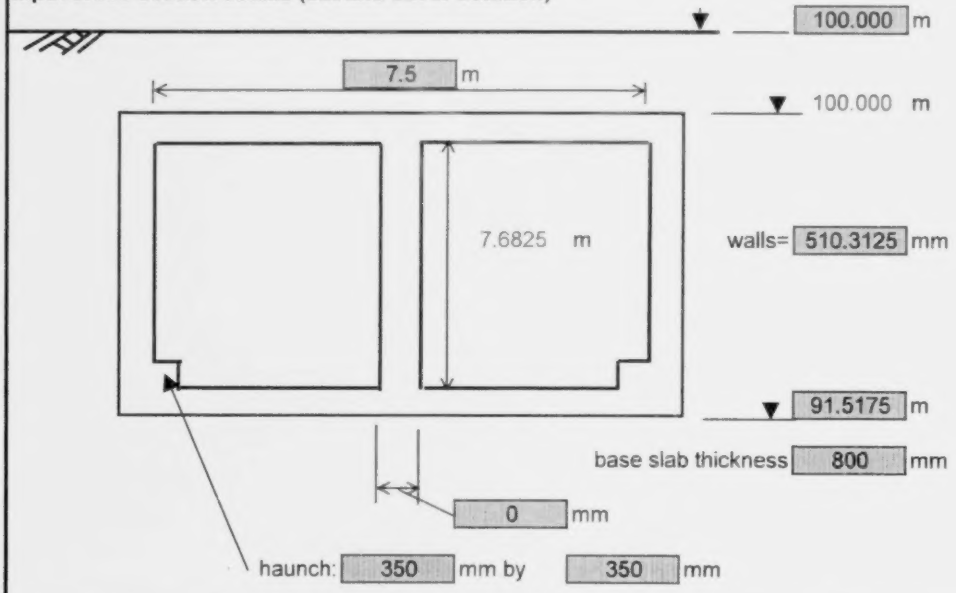
Calculated Quantities

excavation=	5671.7	m3	
concrete=	1169.435	m3	
rebar=	140.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1205.732	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1331.3	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	668.6359	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section 4**

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
7.6825 m
walls= 510.3125 mm
91.5175 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	5671.7	m3	
concrete=	1169.435	m3	
rebar=	140.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1205.732	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1331.3	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	668.6359	m2	

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
Bored Rail Tunnel	**Page 2 of 2**

Calculated costs

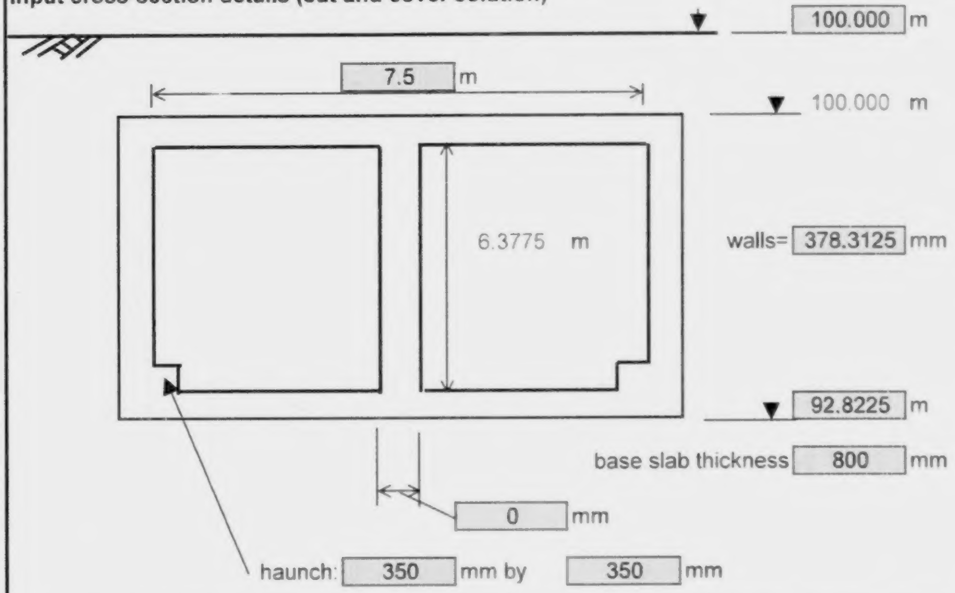
Item	Unit	Quantity	Rate	Cost
excavation	m3	5671.7	60	340302.3
concrete	m3	1169.435	190.0	222192.6
rebar	tonnes	140.3	1600	224531.5
formwork/falsework	m2	1205.732	140	168802.5
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1331.3	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	668.6359	30	20059.08
			Total	975887.9

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 78.47264 m **Section 5**

Input cross-section details (cut and cover solution)



walls= 378.3125 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

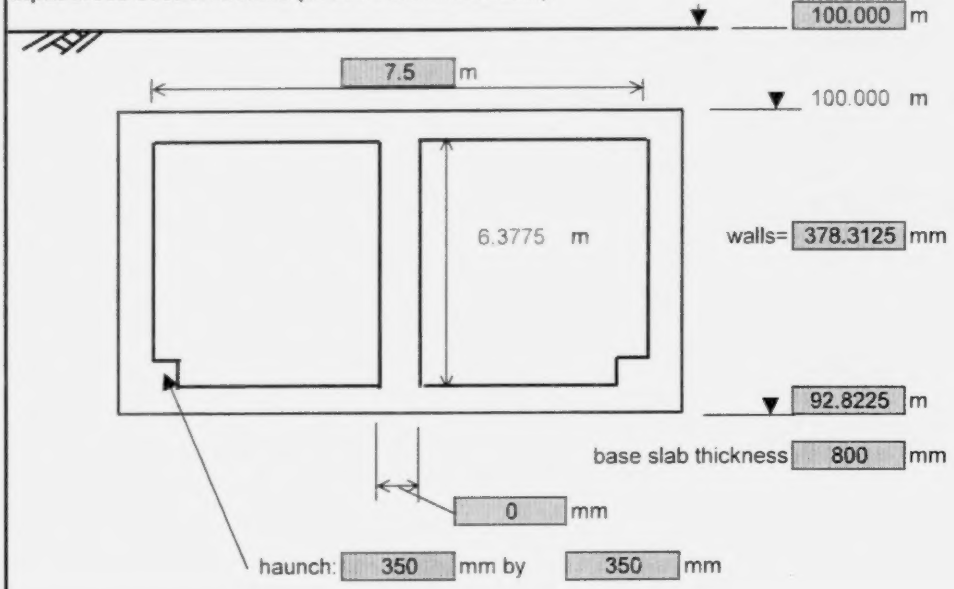
Calculated Quantities

excavation=	4650.4	m3	
concrete=	916.2211	m3	
rebar=	109.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1000.919	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1126.5	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	647.9192	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section** **5**

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
6.3775 m
walls= 378.3125 mm
92.8225 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	4650.4	m3	
concrete=	916.2211	m3	
rebar=	109.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1000.919	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1126.5	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	647.9192	m2	

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
South Approach	**Calculations by:** ANW
Bored Rail Tunnel	**Page 2 of 2**

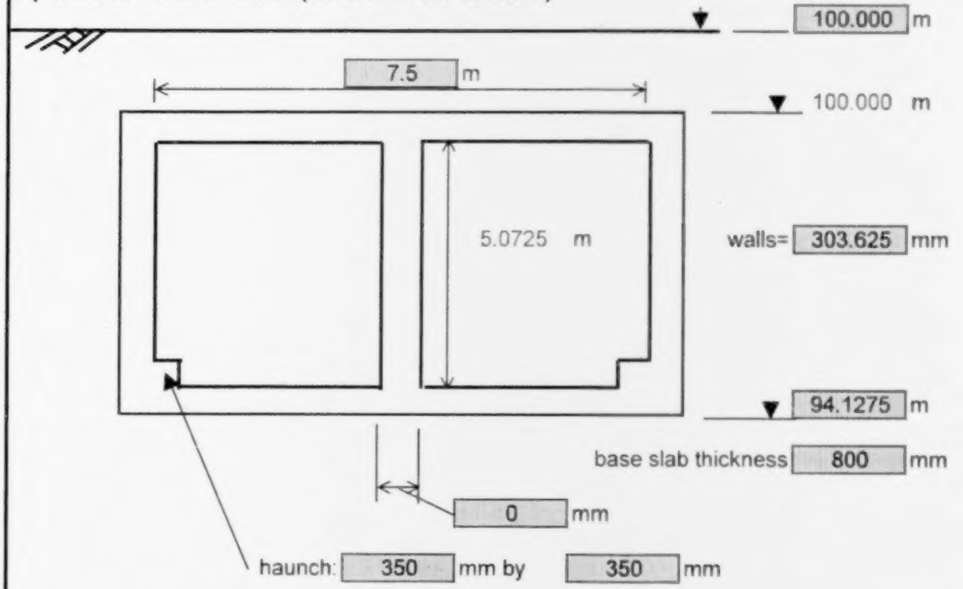
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	4650.4	60	279026.4
concrete	m3	916.2211	190.0	174082
rebar	tonnes	109.9	1600	175914.5
formwork/falsework	m2	1000.919	140	140128.6
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1126.5	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	647.9192	30	19437.57
			Total	788589

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section 6**

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
5.0725 m
walls= 303.625 mm
94.1275 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation= 3736.1 m3
concrete= 769.901 m3
rebar= 92.4 tonnes (assume 0.12t/m3 of concrete)
formwork/falsework= 796.1049 m2
SP&L<=4.6m deep 0.0 m2
4.6<SP&L<=6.7m deep 921.7 m2
6.7<SP&L<=10.6m deep 0.0 m2
10.6<SP&L<=13.7m deep 0.0 m2
13.7<SP&L<=16.8m deep 0.0 m2
16.8<SP&L<=20.0m deep 0.0 m2
20<SP&L<=25m deep 0.0 m2
backfill= 0 m3
surface reinstatement= 636.1973 m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

Calculated costs

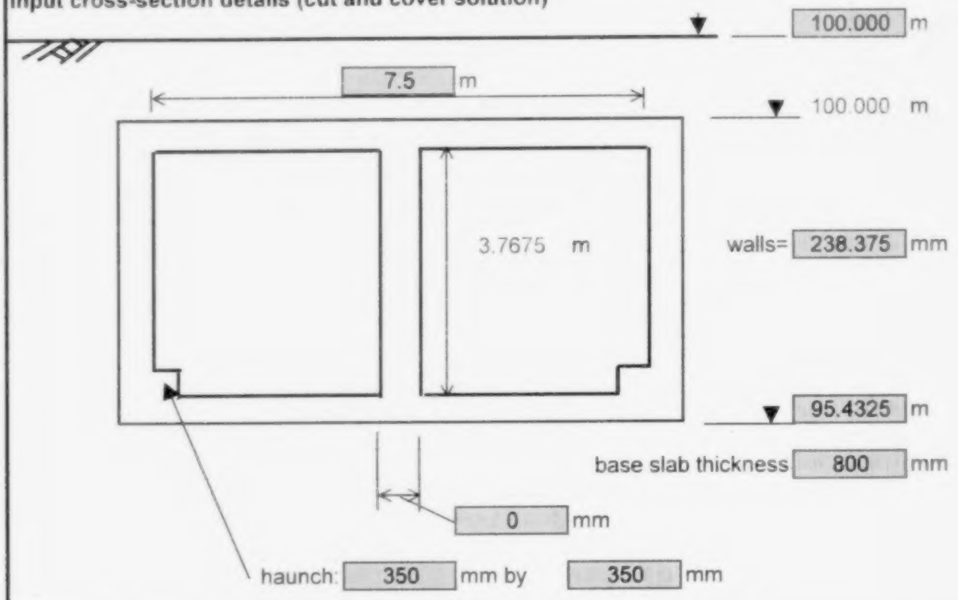
Item	Unit	Quantity	Rate	Cost
excavation	m3	3736.1	60	224164.1
concrete	m3	769.901	190.0	146281.2
rebar	tonnes	92.4	1600	147821
formwork/falsework	m2	796.1049	140	111454.7
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	921.7	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	636.1973	30	19085.92
			Total	648806.9

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 78.47264 m
Section 7

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
3.7675 m
walls= 238.375 mm
95.4325 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation= 2859.1 m3
concrete= 660.9402 m3
rebar= 79.3 tonnes (assume 0.12t/m3 of concrete)
formwork/falsework= 591.2913 m2
SP&L<=4.6m deep 716.8 m2
4.6<SP&L<=6.7m deep 0.0 m2
6.7<SP&L<=10.6m deep 0.0 m2
10.6<SP&L<=13.7m deep 0.0 m2
13.7<SP&L<=16.8m deep 0.0 m2
16.8<SP&L<=20.0m deep 0.0 m2
20<SP&L<=25m deep 0.0 m2
backfill= 0 m3
surface reinstatement= 625.9566 m2

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

Calculated costs

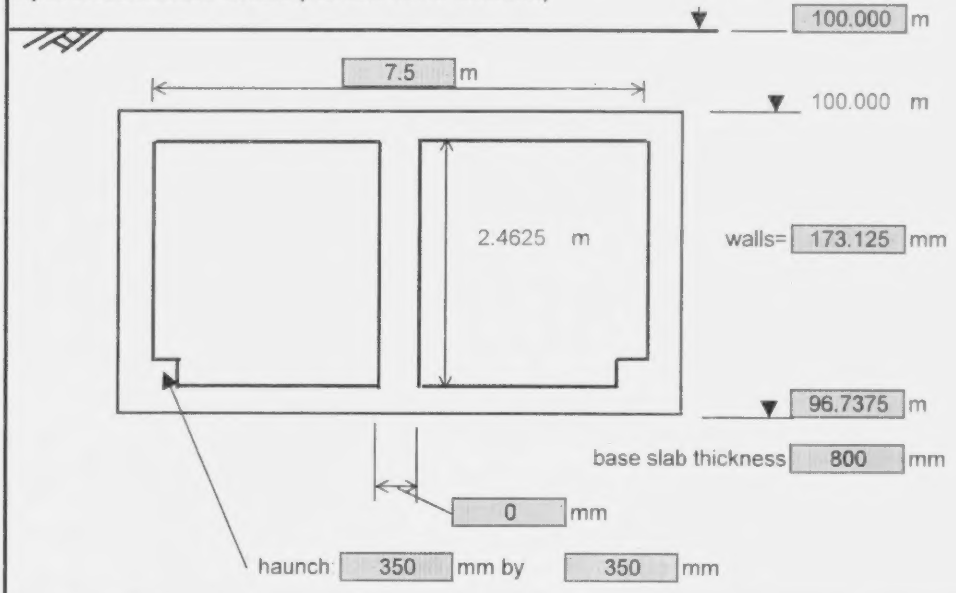
Item	Unit	Quantity	Rate	Cost
excavation	m3	2859.1	60	171543.4
concrete	m3	660.9402	190.0	125578.6
rebar	tonnes	79.3	1600	126900.5
formwork/falsework	m2	591.2913	140	82780.79
SP&L<=4.6m deep	m2	716.8	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	625.9566	30	18778.7
			Total	525582

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 78.47264 m
Section 8

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
2.4625 m
walls= 173.125 mm
96.7375 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	2008.8	m3	
concrete=	578.7075	m3	
rebar=	69.4	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	386.4778	m2	
SP&L<=4.6m deep	512.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	615.716	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

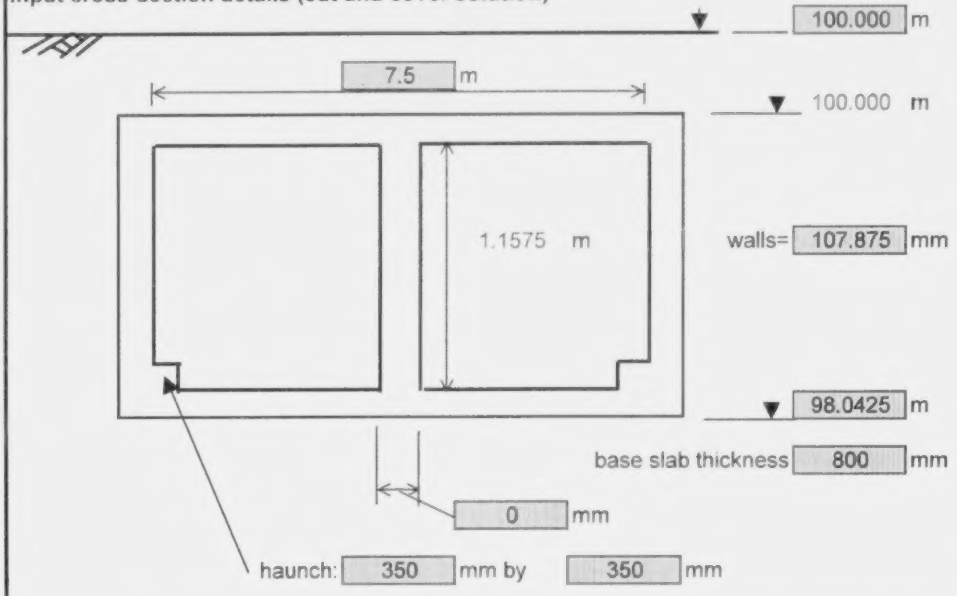
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	2008.8	60	120526.4
concrete	m3	578.7075	190.0	109954.4
rebar	tonnes	69.4	1600	111111.8
formwork/falsework	m2	386.4778	140	54106.89
SP&L<=4.6m deep	m2	512.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	615.716	30	18471.48
			Total	414171

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section 9**

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
1.1575 m
walls= 107.875 mm
98.0425 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	1185.2	m3	
concrete=	523.203	m3	
rebar=	62.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	181.6642	m2	
SP&L<=4.6m deep	307.2	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	605.4753	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

Calculated costs

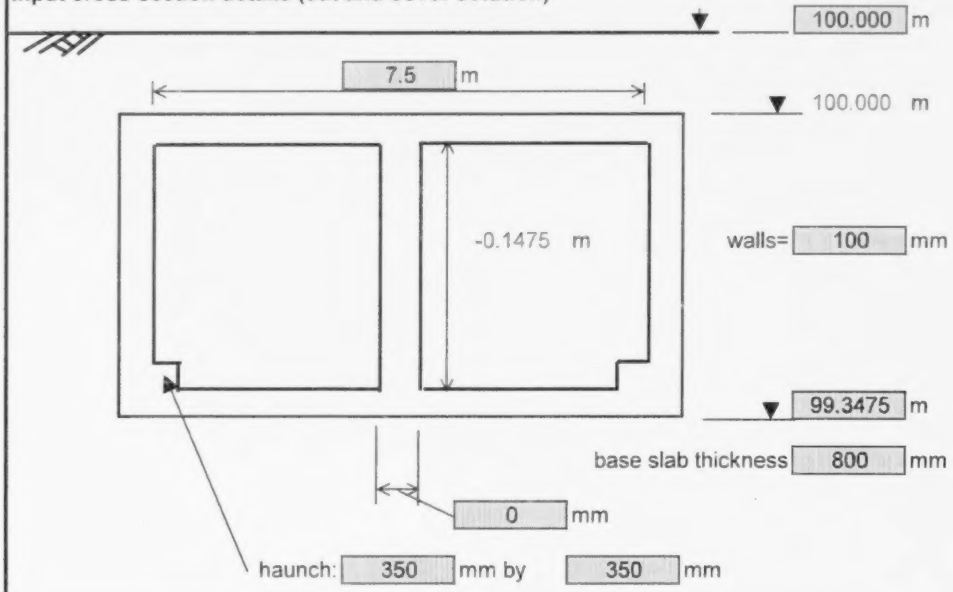
Item	Unit	Quantity	Rate	Cost
excavation	m3	1185.2	60	71113.07
concrete	m3	523.203	190.0	99408.58
rebar	tonnes	62.8	1600	100455
formwork/falsework	m2	181.6642	140	25432.98
SP&L<=4.6m deep	m2	307.2	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	605.4753	30	18164.26
			Total	314573.9

Newfoundland Fixed Link Pre-feasibility Study
South Approach
Bored Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 78.47264 m
Section 10

Input cross-section details (cut and cover solution)



walls= 100 mm
base slab thickness 800 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	394.3	m3	
concrete=	500.3023	m3	
rebar=	60.0	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	-23.14943	m2	
SP&L<=4.6m deep	102.4	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	604.2393	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel **Page 2 of 2**

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	394.3	60	23655.97
concrete	m3	500.3023	190.0	95057.44
rebar	tonnes	60.0	1600	96058.04
formwork/falsework	m2	-23.14943	140	-3240.92
SP&L<=4.6m deep	m2	102.4	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	604.2393	30	18127.18
			Total	229657.7

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Bored Rail Tunnel

Summary of Costs

Markup for adjacent 0 %

Section	Cost
1	1589250
2	1442071
3	1225243
4	975887.9
5	788589
6	648806.9
7	525582
8	414171
9	314573.9
10	229657.7
Sub-total	8153832

Newfoundland Fixed Link Pre-feasibility Study
Tunnel Drainage
Bored Railway Tunnel
Drainage Costs

Page 1 of 1
Calculation by: ANW
Date: June 8, 2004

Sump Sizing

Assume inflow to tunnel of 1 litres/m2/24hours

Tunnel length= 28000 m
Tunnel diameter= 7.5 m

24 hour inflow= 1237002 litres = 1237 m3
assume same again for firefighting= 1237 m3

Required sump capacity= 2474 m3

Assumed sump diameter= 6 m
Assumed number of sump structures= 2 m

Required length of each sump= 44 m

Piping

Assume 300 mm diameter steel pipe connecting each sump to the portal areas
Number of pipes= 1
Assume sumps located at 1/3 and 2/3 of tunnel length

Total length of piping= 18967 m

Rates

Sump construction-$ 17795 /m of sump
Pipe-$ 265 /m of pipe
Pipe installation labour -$ 29 /m of pipe (assume 6 man crew installing 100m/day)
Pipe installation equipment-$ 10 /m of pipe (assume $1000/day for equipment)
Pumps-$ 125000 /pump

Costs

Item	Unit	Qty	Rate	$-Cost
Sump construction	m	88	17795	1,565,960
Pipe	m	18967	265	5,026,167
Pipe installation	m	18967	29	546,240
Equipment	m	18967	10	189,667
Pumps	Nr	4	125000	500,000
			Total	7,828,033

Newfoundland Fixed Link Pre-feasibility Study	**Page 1 of 1**
Tunnel Drainage	**Calculation by:** ANW
Bored Railway Tunnel	**Date:** June 8, 2004
Drainage Costs	

Sump Sizing

Assume inflow to tunnel of 1 litres/m2/24hours

Tunnel length= 28000 m
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Assume sumps located at 1/3 and 2/3 of tunnel length

Total length of piping= 18967 m

Rates

Sump construction-$	17795	/m of sump	
Pipe-$	265	/m of pipe	
Pipe installation labour -$	29	/m of pipe	(assume 6 man crew installing 100m/day)
Pipe installation equipment-$	10	/m of pipe	(assume $1000/day for equipment)
Pumps-$	125000	/pump	

Costs

Item	Unit	Qty	Rate	$-Cost
Sump construction	m	88	17795	1,565,960
Pipe	m	18967	265	5,026,167
Pipe installation	m	18967	29	546,240
Equipment	m	18967	10	189,667
Pumps	Nr	4	125000	500,000
			Total	7,828,033

Newfoundland Fixed Link
Estimation of Capital Cost of Rail System

Table 2 - Estimated Capital Cost, not including Real Estate

	Item	*Qty*	*Unit*	*Unit Price*	*Cost*
A	Rolling Stock				
	Locomotive -	5	Ea	2,750,000	13,750,000
	Transfer cars (std + 25% for mods)	7	Ea	162,671	1,138,699
	Auto/truck carriers (std + 25% for mods)	42	Ea	214,041	8,989,726
	Trackmobile	1	Ea	75,000	75,000
B	Trackwork				
	Track at terminals (incl. subgrade & ballast)	5,060	m	500	2,530,000
	#20 Turnouts	4	Ea	150,000	600,000
C	OCS System				
	OCS in tunnel	1	Ea	4,062,629	4,062,629
	OCS at terminals	2	Ea	1,068,271	2,136,543
	OCS at Maint. Facility	1	EA	28,214	28,214
	Substations	2	Ea	1,535,714	3,071,429
D	Train Signal System				
	Microprocessor Based Signaling System	1	Ea	4,472,000	4,472,000
	Powered derails	2	Ea	60,000	120,000
	Power service to bungalows and wayside cabinets	1	Ea	500,000	500,000
	Fibre optical cable and correspondance equipment	1	Ea	1,000,000	1,000,000
	Radio system	1	Ea	500,000	500,000
E	Loading/Unloading Facility				
	Staging area (incl. ramps, lighting)	50,000	m^2	25	1,250,000
	Loading control system (incl. CCTV)	2	Ea	250,000	500,000
	Operations building (complete)	120	m^2	1,800	216,000
	Public facilities building (complete)	50	m^2	1,600	80,000
F	Maintenance & Emergency Response				
	Train maintenance bldg	1,200	m^2	2,000	2,400,000
	Site maintenance bldg	144	m^2	1,500	216,000
	Emergency evacuation bus w/ high rail gear	2	Ea	100,000	200,000
	Snow plow	2	Ea	100,000	200,000
	Pick-up truck with high rail gear	2	Ea	60,000	120,000
	SUV	2	Ea	50,000	100,000
	Tunnel fire engine (high rail mounted)	2	Ea	180,000	360,000

TOTAL COST OF SHUTTLE TRAIN OPERATION EXCLUDING REAL ESTATE $ 48,616,239

Newfoundland Fixed Link Pre-feasibility Study
Rail Tunnel

Estimation of annual operating and maintenance costs

A. Energy Costs

1. Tunnel lighting	3000000	kWh/yr @	0.1	$/kWh=	$	300000	/yr
2. Ventilation fans	400000	kWh/yr @	0.1	$/kWh=	$	40000	/yr
3. Sump pumps	20000	kWh/yr @	0.1	$/kWh=	$	2000	/yr
				Sub-total A -	$	342000	/yr

B. Electrical Maintenance Costs

1. Labour (Assume 1 electricians for 5 days per week throughout year)

Electrician 1	2080	hrs/yr @	65	$/hr=	$	135200	/yr

2. Materials/replacement of equipment (assume electrical equipment replaced once every 40 years)

Electrical equipment cost=	$ 1000000						
	written-off over		40	years =	$	25000	/yr
				Sub-total B -	$	160200	/yr

C. Mechanical Maintenance Costs

1. Labour (Assume 1 mechanic/maintenance technician for 5 days per week throughout year)

Mechanic	2080	hrs/yr @	65	$/hr=	$	135200	/yr

2. Materials/replacement of equipment (assume mechanical equipment replaced every 40 years)

Ventilation system cost=	$ 1000000						
	written-off over		40	years =	$	25000	/yr
Emergency generators=	$ 500000						
	written-off over		40	years =	$	12500	/yr
Drainage pumps cost=	$ 200000						
	written-off over		40	years =	$	5000	/yr
				Sub-total C -	$	177700	/yr

contd.

Estimation of annual operating costs

D. Structure Maintenance Costs

1. Inspection (assume 3 man inspection crew for 10 weeks once every 4 years)

Senior engineer	100	hrs/yr @	130	$/hr=	$	13000	/yr
Engineer 1	100	hrs/yr @	100	$/hr=	$	10000	/yr
Engineer 2	100	hrs/yr @	100	$/hr=	$	10000	/yr

2. Tunnel Cleaning (Assume 4 man crew for 13 weeks once a year)

Labourers	2080	hrs/yr @	60	$/hr=	$	124800	/yr

3. Sump clean-up (Assume 2 man crew for 2 days twice a year)

Labourers	64	hrs/yr @	50	$/hr=	$	3200	/yr

4. Structure maintenance (Assume 4 man crew for 13 weeks once a year)

Labourers	2080	hrs/yr @	50	$/hr=	$	104000	/yr

5. Permanent Way Inspection (Assume 2 men inspect track 3 times per week)

Labourers	312	hrs/yr @	50	$/hr=	$	15600	/yr

6. Permanent way maintenance (Assume 4 man crew for 12 weeks once a year)

Labourers	1920	hrs/yr @	50	$/hr=	$	96000	/yr
				Sub-total D -	$	215600	/yr

Total estimated maintenance cost=$ 895,500 /yr

Newfoundland Fixed Link
Rail System – Estimation of Annual Operating Cost

Table 3 - Estimated Shuttle Service Annual Operating Cost

	Item				*Annual Cost*
	Assumptions *Facility operates 12 hours/day, 7 days/week. 30 percent of this time the facility is fully staffed with toll collectors, the remainder of the time only 1 toll booth is operating on each side.*				
A	Salaried Staff	*Mult.*	*Unit*	*Rate*	
	Tunnel Manager	1.40	Year	100,000	140,000
	Tunnel Operator	1.40	Year	100,000	140,000
	Apprentice Operator	1.40	Year	60,000	84,000
	Site Maintenance Mgr	1.40	Year	50,000	70,000
B	Hourly Staff	*Quant*	*Unit*	*Rate*	
	Toll collectors - (2 FT, 4 PT, 1 PT Spare)	7,000	h	50	350,000
	Site Labor	4,000	h	35	140,000
	Electricians	6,000	h	65	390,000
	Mechanics	6,000	h	60	360,000
	Train drivers	8,000	h	85	680,000
	Loading foreman	4,000	h	55	220,000
	Laborers	20,000	h	40	800,000
C	Subcontracted Work				
	Locomotive maintenance	1	LS	120,000	120,000
	Rolling stock maintenance	1	LS	25,000	25,000
	Facility cleaning	52	w	250	13,000
	Landscaping	52	w	500	26,000
	Building maintenance	1	LS	10,000	10,000
D	Power	*Quant*	*Unit*	*Rate*	
		8,922	MW-h	60	535,324
E	Equipment Depreciation (straight-line)	*Life*	*Unit*	*Cap. Cost*	
	Locomotives (20 years)	20	Year	13,750,000	687,500
	Rolling stock (20 years)	20	Year	10,128,425	506,421
	Buildings	30	Year	2,912,000	97,067
	Roads	30	Year	1,250,000	41,667
	Trackwork	25	Year	3,130,000	125,200
	OCS system	15	Year	9,298,814	619,921
	Signal system	15	Year	6,592,000	439,467
	Train loading system	12	Year	500,000	41,667
	Heavy vehicles	12	Year	560,000	46,667
	Light trucks	7	Year	220,000	31,429
	TOTAL ANNUAL OPERATING COST OF SHUTTLE TRAIN				$ 6,740,328

Newfoundland Fixed Link Pre-feasibility Study
Road Connections
Cost Estimate Summary

The following is a summary of the costs of road works associated with the project.

			Unit	Quantity	Unit Cost	Total Cost
1		**Road Tunnel Concept**	Unit	Quantity	Unit Cost	Total Cost
1A		**Newfoundland Side**				
	0.1	New Road Construction	km	1.4	$550,000	$770,000
	0.2	Intersection Construction	allowance	1	$50,000	$50,000
	0.3	Marshalling Area	sq meter	36,000	$45	$1,620,000
		Sub Total Nfld Side				$2,440,000
1B		**Labrador Side**				
	0.1	New Road Construction	km	1	$600,000	$600,000
	0.2	Intersection Construction	allowance	1	$50,000	$50,000
	0.3	Marshalling Area	sq meter	36,000	$57	$2,052,000
		Sub Total Labrador Side				$2,702,000
2		**Rail Tunnel Concept**	Unit	Quantity	Unit Cost	Total Cost
2A		**Newfoundland Side**				
	0.1	New Road Construction	km	1.5	$550,000	$825,000
	0.2	Intersection Construction	allowance	1	$50,000	$50,000
	0.3	Marshalling Area	sq meter	36,000	$45	$1,620,000
		Sub Total Nfld Side				$2,495,000
2B		**Labrador Side**				
	0.1	New Road Construction	km	1	$600,000	$600,000

0.2	Intersection Construction	allowance	1	$50,000	$50,000
0.3	Marshalling Area	sq meter	36,000	$57	$2,052,000
	Sub Total Labrador Side				$2,702,000

3		**Quebec North Shore**				
	0.1	New Road Construction	km	350	$720,000	$252,000,000
	0.2	Road Upgrading	km	40	$360,000	$14,400,000
	0.3	Branch Roads	km	20	$312,000	$6,240,000
	0.4	Bridges	ea	9	$1,200,000	$10,800,000
		Sub Total Quebec North Shore Roads				$283,440,000
Total Road Costs						
		Road Tunnel				$288,582,000
		Rail Tunnel				$288,637,000

Hatch Mott MacDonald

Newfoundland Fixed Link Pre-feasibility - Drill & Blast Railway Tunnel - Cost Summary

BORED TUNNEL CONSTRUCTION COSTS		
ITEM	UNIT	**MAIN TUNNEL**
MOBILIZATION & DEMOBILIZATION	LS	**8,000,000**
DRILL & BLAST TUNNELLING	LS	**606,989,049**
TUNNEL FINAL LINER	LS	**180,499,146**
TUNNEL FINISHES	LS	**171,353,089**
NORTH APPROACH STRUCTURES	LS	**8,153,832**
SOUTH APPROACH STRUCTURES	LS	**8,153,832**
RAIL TRACK	LS	**16,086,400**
TUNNEL DRAINAGE	LS	**7,820,000**
UTILITY DIVERSIONS	LS	**1,000,000**
MONITORING	LS	**1,000,000**
SUBTOTAL CIVIL		**$1,009,055,348**
CIVIL CONTINGENCIES		
CONTINGENCY	40%	$403,622,139
TOTAL CIVIL		**$1,412,677,487**
M&E, ROLLING STOCK, RAIL HARDWARE AND FINISHING WORK		
ROLLING STOCK, TERMINALS, OCS, ETC	LS	$48,000,000
VENTILATION EQUIPMENT	LS	$3,000,000
VENTILATION SHAFTS AND BUILDINGS x 2	LS	$0
FIRE SUPPRESSION SYSTEM	LS	$2,000,000
CONTROL CENTRE	LS	$1,000,000
SIGNALLING	LS	$1,000,000
LIGHTING	LS	$1,000,000
CCTV SYSTEM	LS	$0
GAS DETECTION	LS	$900,000
SUBSTATION, GENERATORS, UPS	LS	$2,000,000
SUBTOTAL M&E AND FINISHING		**$58,900,000**
CONTINGENCIES	20%	$11,780,000
TOTAL M&E AND FINISHING		**$70,680,000**
TOTAL CIVIL, M&E AND FINISHING		**$1,483,357,487**
ALLOWANCES		
CONTRACTOR OH	15%	$222,503,623
CONTRACTOR PROFIT	15%	$222,503,623
CONSTRUCTION TOTAL		**$1,929,000,000**
PRE-CONSTRUCTION AND SUPERVISION		
FEASIBILITY STUDY	LS	$11,000,000
ENVIRONMENTAL ASSESSMENT	LS	$4,000,000
DESIGN	5%	$96,450,000
CONSTRUCTION MANAGEMENT	10%	$192,900,000
OWNERS COSTS	2%	$38,580,000
PRE-CONSTRUCTION TOTAL		$342,930,000
GRAND TOTAL		**$2,271,930,000**

APPENDIX D (8)

DRILL & BLAST RAIL TUNNEL COSTS

Tunnel Estimating Database

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Version VANC-1.0

Project:	Newfoundland Fixed Link Study	**Project Number:**	213789
Estimate Description:	Prefeasibility Level		
		Project Phase:	Prefeasibility Design
		Estimate Date:	June 11 2004

Newfoundland Fixed Link Study
Prefeasibility Level

213789

Prefeasibility Design

June 11 2004

STRUCTION AND SUPERVISION

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Version VANC-1.5

P:\MEMORIAL 213789 DESC Cost Estimating & Scheduling [illegible] - End Sept Final [illegible] [Nwfld Cost - Rail - June 11 2004 [illegible]]V-315

Project:	**Newfoundland Fixed Link Study**	**Project Number:**	213789
Estimate Description:	Prefeasibility Level	**Parent Estimate ID:**	V-300
Tunnel Name:	Railway Tunnel - Down Drive	**Project Phase:**	Prefeasibility Design
Construction Activity:	Excavation (Drill & Blast) & Initial Support	**Geology Type:**	Poor to Fair Sediments & Volcanics
Estimate Definition ID:	V-315	**Estimate Date:**	June 11 2004

Tunnel Characteristics

Tunnel Length:	**15,333.0**		m
Design Width:	**6.4**		m
Design Wall Height (Ave.)	**6.6**		m
Design Wall to Roof:	**2.5**		
Design Max Height :	9.1		m
Ave Tunnel Overbreak:	**20.0**		cm
Tunnel Face Area:	59.3	(Includes Overbreak)	m^2
Crown Perimeter:	9.6	(Includes Overbreak)	m
Wall & Crown Perimeter:	23.2	(Includes Overbreak)	m
Wall & Crown Area:	355,933	(Includes Overbreak)	m^2
Neat Tunnel Excav. Vol.:	909,246	(Includes Overbreak)	m^3
Re-Muck / Pull-Out Bays:			
Bay Length:	**10.0**		m
Spacing Bttn Bays:	**1000.0**		m
Number of Bays:	15		No.
Total Length of Bays:	150.0		m
Neat Excavation Vol.:	8,895		m^3
Total Tunnel Volume:	918,141		m^3
Muck Bulking Factor:	**1.6**		Ratio
Bulked Tunnel Volume:	1,469,025	(Loose Muck Volume)	m^3

Primary Mucking Production Details

(Activity to remove blast muck from face to conveyor & muck cars)

Muck Volume / Blast:	313.1		m^3
Mucking Volume / Trip:	**5.00**		m^3
Bucket Fill Factor (%):	**90.0**		%
Number of Trips:	70		No.
Ave. Dist. to Load:	**35.0**	(Ave Distance One Way)	m
Ave. Tramming Speed:	**8.0**		km/hr
Load, Dump, Manoever:	**1.0**	(Time per Trip)	Min
Face Cleanup / Blast:	**15.0**		Min
Mucking Time:	2.0		Hours
Mucking Rate:	155.1		m^3 / Hour

Tunnel Support Class Details

Class I - No Support:	**0.0**	(%)	0	(m)
Class II - Spot Bolts:	**0.0**	(%)	0	(m)
Class III - Crown Only:	**40.0**	(%)	6,133	(m)
Class IV - Full Pattern:	**50.0**	(%)	7,667	(m)
Class V - Steel Sets:	**10.0**	(%)	1,533	(m)
Total	100.0		15,333	(m)

Initial Shotcrete Support Details

Support Arc Length:	**23.2**	m
Thickness:	**25.0**	mm
Volume / Round:	2.2	m^3

Shift Details

Shift Arrangement:	**3.0**	Shifts / Day
	8.0	Hours / Shift
	7.0	Days / Week

Drill, Charge, Blast, Vent & Mucking Details

Survey Tunnel / Holes / Map:	**30.0**	Min / Cycle
Drilling Blast Holes:		
Hole Length:	**3.9**	m / Hole
Perim. Blast Hole Spacing:	**0.50**	m
Interior Blast Hole Spacing:	**1.25**	m
No. Perimeter Holes:	46	No.
No. Interior Area Holes:	38.0	No
No. Blast Initiation Holes:	14	No.
Number of Drillholes / Blast:	99	Blastholes / Blast
Blast Hole / Face Area Ratio:	1.67	Holes / m^2
Typical / Check Ratio:	1.56	Holes / m^2
Drill Eqpt Set-Up Time:	**40**	min / Set-up
Drill Penetration Rate:	**0.30**	m / Min
	18	m/hour
# of Drills or Booms:	**3.0**	No
Charging & Blasting:		
Prime & Load Rate / Hole:	**2.50**	min / Blasthole
Prep & Hook-up Time:	**40.0**	min / Set-up
Total No. Blasts / Tunnel:	4692	No.
Net Blast Break Length:	**3.3**	m / Blast
Blast & Ventilation Time:	**1.0**	Hours

Pre-Excavavation Grouting Details

% Tunnel to be Grouted:	**10.0**	%
Tunnel Length to Grout:	1533	m
Grout Hole Length:	**7.0**	m
No. of Grouting Applications:	219	No.
Perim. Grout Holes Spacing:	**1.50**	m
# Perim. Grout Holes:	15	Holes / Grout Cycle
Drilling Penetration Rate:	**50**	m/hour
No. of Drill Booms:	**2**	No.
Drilling Time per Cycle:	237	Min
Grout Eqpt. Set-Up Time:	**1.0**	Hours / Grout Cycle
No. of Holes Grouted at Once:	**2**	Hoses
Grouting Injection Rate:	**10**	min / Drillhole
Full Grout Cycle Time:	122.7	Hours

Steel Set Installation Details

Steel Set Spacing:	**1.0**	m
Total No. Sets / Tunnel:	1,533	No
Ave. Installation Time / Set:	**3.0**	Hours

Estimated by ____PJP____
Checked by ____________

Time:	0.8 (Includes Scaling & Equip Set-up)	Hours	**Total Installation Time:**	4,600	Hours

Estimated by: ____PJP____
Checked by: __________

Wiremesh Installation Details

Install Rate:	**100**	m² / Hour
Total Install Time:	3,924.2	Hours
Ave. Install Time:	50.2	Min
Overlap:	**5**	%
Net Applied Area:	**355,933** (Assume Class V only)	m²
Area with Overlap:	392,416	m²

Final Shotcrete Support Class Details

Shotcrete Thickness:		
Classes I and II:	**0**	mm
Class III:	**0**	mm
Classes IV:	**50**	mm
Class V:	**100**	mm
Support Arc Length:		
Class I:	**0.0**	m
Class II:	**0.0**	m
Class III:	**0.0**	m
Class IV:	**23.2**	m
Class V:	**23.2**	m

Initial and Final Shotcrete Application Details

Net Volume:	12,458		m³
Rebound / Waste:	**15**		%
Final Layer Volume:	14,326		m³
No. of Applications:	**2695**	(Required Per Bench)	No.
Ave. Vol. / Application:	5.3		m³
Surface Prep Time:	**10.0**		Min
Total Surface Prep Time:	26,949		Min
Application Rate:	**24.0**		m³ / Hour
Total Application Time:	35,816		Min
Eqpt. Setup Time:	**20.0**		Min
Total Setup Time:	53,898		Min
Eqpt. Remove Time:	**10.0**	(Required Per Application)	Min
Total Remove Time:	26,949		Min
Total Shotcreting Time:	143,611	(For Final Shotcrete Layer)	Min
Equivalent Time / Blast:	30.6		Min / Cycle

Secondary Mucking Details

Req'd during Tunneling:	No	(No if loaded directly into trucks in tunnel)	
Ave. LHD Tram Speed:	**0.0**		km / hour

Wick Drain Installation Details

Drain Spacing:	**0.0**	m
Installation Time / Row:	**0.0**	Hours / Drain

Average Tunneling Productivity Cycle Details

Equiv. Pre-Exc. Grouting:	5.7		Hours
Drilling:	7.8		Hours
Charging:	4.8		Hours
Blast & Venting:	1.0		Hours
Mucking:	2.0		Hours
Scaling:	0.3		Hours
Surveying / Mapping:	0.5		Hours
Initial Shotcreting:	0.8		Hours
Install Services:	**0.5**	(Equiv. Time Per Cycle)	Hours
Non-Productive Time:	**0.5**	(Travel in/out, Break)	Hours
Include Rockbolting:	Yes	(Yes / No, as part of Cycle Time)	
If yes, % of Support Rq'd:	**30**	(% Req'd During Cycle for Poorer Ground)	
Rockbolting:	0.3		Hours
Total Cycle Time:	24.3		Hours

Rockbolt Support Class Details

	(Bolts Per Row)	(Bolts Per m)	(Bolts Per Support Class)
Class I:	**0**	0.0	0
Class II:	**0.0**	0.0	0
Class III:	**6**	4.0	24,533
Class IV:	**15**	10.0	76,665
Class V:	**0**	0.0	0
Total:			101,198

Face Scaling

Scaling Time:	**20.0**	min / Blast

Rockbolt Installation Details

Rockbolt Length:	**3.0**	m
Row Spacing:	**1.5**	m
No. Rockbolts Required:	101,198	No.
Ave. Bolts / Round:	21.8	Bolts / Blast
Drilled Length / Round:	65	m
Total Drilling Length:	303,593	m
Drill Penetration Rate:	**1.5**	m / Min
# of Drills / Booms Used:	**3**	No.
Ave. Drilling Time / Round:	14.5	Min
Bolt Install Rate	**2.0**	Min / Bolt
Ave. Bolt Install Time:	43.6	Min
Drill Set-Up Time:	**10.0**	Min
Total Bolt Drill/Install Time:	68.1	Min

Drainhole Details

Drainhole Spacing:	**3.0**	m
Drainhole Length:	**1.1**	m
Total Area:	177,966.3	m²
Total Drainholes:	19,774.0	# / Per Tunnel
Total Length:	21,751.4	m

Note: Activity carried out concurrent with other activities

Duration of Tunneling:

Pre-Exc. Grouting Time =	26,866.9	Hours
Drilling Time =	36,596.4	Hours
Charge, Blast, Vent Time =	27,128.5	Hours
Primary Mucking Time =	9,470.2	Hours
Scaling Time =	4,692.2	Hours
Survey / Map Time =	2,345.9	Hours
Install Steel Sets Time =	4,599.9	Hours
Initial Shotcreting Time =	3,558.4	Hours
Install Services Time =	2,345.9	Hours
Rockbolting (of % Critical) =	1,597.1	Hours
Non-Productive Time =	2,345.9	Hours
Total Time =	121,547.3	Hours
	167.0	Months
(Critical Path Tunneling Activities Only)	723.5	Weeks
	5,064.5	Days

Other Concurrent Tunneling Activities

Rockbolting (of % Not Critical) =	3,726.6	Hours
Wiremesh Installation =	3,924.2	Hours
Final Shotcreting Time =	0.5	Hours
Drilling Drainholes =	29,001.9	Hours
Secondary Mucking =	0.0	Hours
Wick Drain Installation =	0.0	Hours

Overall Advance Rate:

3.0	m / Day
179.5	m³ / Day

Estimated by PJP
Checked by

Resource Type	Resource Name	Unit Rate	Unit	Quantity	Resource Quantity	Total
Labor						
	Miner - Shift Boss	50.68	$/hr	121,547.3	2.00	12,320,036.24
	Miner - Operator - Journeyman	47.84	$/hr	121,547.3	11.00	63,963,061.06
	Miner - Foreman	50.68	$/hr	121,547.3	3.00	18,480,054.35
	Miner - Laborer - Journeyman	47.40	$/hr	121,547.3	5.00	28,806,714.56
	Miner - Laborer - Apprentice	45.00	$/hr	121,547.3	5.00	27,348,146.73
	Tunnel Electrician - Journeyman	47.84	$/hr	121,547.3	4.00	23,259,294.93
					30.00	174,177,307.87
Plant						
	Cable - Fans & Pumps - High Voltage	120.00	$/m	15,333.0	0.20	367,992.00
	Cable - Lights / Controls - Low Voltage	10.00	$/m	15,333.0	0.80	122,664.00
	Compressor	45.61	$/wk	723.5	1.00	33,000.00
	Conveyor - Heading Muck Loading	1,788.19	$/wk	723.5	1.00	1,293,750.00
	Drill - Jack-Leg	29.03	$/wk	723.5	4.00	84,000.00
	Drill Jumbo - Rail Mounted - 2 Boom	362.82	$/wk	723.5	1.00	262,500.00
	Drill Jumbo - Rail Mounted - 3 Boom	518.32	$/wk	723.5	1.00	375,000.00
	Excavator - Rail Mounted	114.03	$/wk	723.5	1.00	82,500.00
	Generator - Back-Up - 500KW	108.85	$/wk	723.5	1.00	78,750.00
	Generator - Working - 1000KW	812.72	$/wk	723.5	1.00	588,000.00
	Grout Plant-Consol-D&B-Pump, Hoses	68.42	$/wk	723.5	1.00	49,500.00
	Lighting (Including Consumables)	7.50	$/m	15,333.0	1.00	114,997.50
	Locomotive - Diesel - 16T	5,000.00	$/wk	723.5	4.00	14,469,918.91
	LHD Loader - D&B Tunnel	347.79	$/wk	723.5	1.00	251,625.00
	Manlift / Platform - Rail Mounted	152.04	$/wk	723.5	1.00	110,000.00
	Pipe - 50mm (Water Supply)	7.50	$/m	15,333.0	1.00	114,997.50
	Pipe - 100mm (Air Supply)	15.00	$/m	15,333.0	1.00	229,995.00
	Pipe - 150mm (DeWatering)	25.00	$/m	7,666.5	1.00	191,662.50
	Pipe - 250mm (Dewater)	70.00	$/m	7,666.5	1.00	536,655.00
	Pipe - Dewatering Clamps (<=200mm)	7.00	$/m	15,333.0	1.00	107,331.00
	Pumps - Dewatering - Tunnel - 50HP	34.89	$/wk	361.7	15.00	189,337.50
	Rail - 80 lb/yd - Used	101.54	$/m	31,066.0	0.60	1,892,636.31
	Rail - California Switch Gear	75,000.00	$/Nr	1.0	3.00	225,000.00
	Rail Car - Flat	50,000.00	$/Nr	1.0	3.00	150,000.00
	Rail Car - Man Rider	50,000.00	$/Nr	1.0	1.00	50,000.00
	Rail Car - Muck Cars	1,900.00	$/wk	723.5	18.00	24,743,561.33
	Rail Car - Muck Car Tipping System	75,000.00	$/Nr	1.0	1.00	75,000.00
	Shotcrete Machine - Rail Mounted	166.90	$/wk	723.5	1.00	120,750.00
	Shotcrete Machine - Tire Mounted	270.22	$/wk	723.5	2.00	391,000.00
	Small Tools	200.00	$/wk	723.5	1.00	144,699.19
	Tie Plates, Splice Bars, Bolts	150,000.00	LS	1.0	1.00	150,000.00
	Ties - Wooden - Untreated - 7" x 9" x 40"	23.00	$/m	15,333.0	1.00	352,659.00
	Transformers & Switchgear - High Voltag	76.02	$/wk	723.5	1.00	55,000.00
	Transformers-Switchgear-Low Voltage	38.01	$/wk	723.5	1.00	27,500.00
	Ventilation Duct - Rigid	110.00	$/m	15,333.0	1.00	1,686,630.00
	Ventilation Fans - 75HP	21.46	$/wk	723.5	7.00	108,675.00
	Welder (Plant)	2.38	$/wk	723.5	1.00	1,725.00
						49,829,011.74

Estimated by: PJP

Checked by: ______

Resource Type	Resource Name	Unit Rate	Unit	Quantity	Resource Quantity	Total
Consumables						
	Bits, Powder and Caps - Blasting	15.00	$/m3	918,140.5	1.00	13,772,107.66
	Bits - (Drainholes & Rockbolts)	5.00	$/m	325,344.8	1.00	1,626,724.21
	Drill Jumbo Maintenance	100.00	$/hr	34,995.8	1.00	3,499,575.81
	Electricity - Tunnel Heading Conveyor	0.22	$/kwh	150	1,172.95	38,707.50
	Electricity - Fans & Lighting	0.22	$/kwh	437	60,773.66	5,849,350.37
	Electricity - Jumbo	0.22	$/kwh	75	34,995.76	577,430.01
	Electricity - Pumps Dewatering	0.22	$/kwh	559	85,083.12	10,468,668.61
	Lubricants	2,500.00	$/wk	723.5	1.00	1,808,739.86
	Fuels & Lubricants	5,000.00	$/wk	723.5	1.00	3,617,479.73
	Other Consumables	1,500.00	$/wk	723.5	1.00	1,085,243.92
						$ 42,344,027.69
Materials						
	Grout - Consolidation	50.00	$/m3	2,000.0	1.00	100,000.00
	Other Materials	2,000.00	$/wk	723.5	1.00	1,446,991.89
	Rock Bolts - No.10 - 3.0m - (Non-Galv)	40.00	$/Nr	101,198	1.00	4,047,912.00
	Shotcrete	180.00	$/m3	14,326.3	1.00	2,578,732.41
	Steel Sets - W10 x 65	152.75	$/m	1,533	23.21	5,436,871.99
	Synthetic Wick Drains	5.00	$/m	0	1.00	-
	WWF mesh	5.50	$/m2	392,416	1.00	2,158,286.91
						$ 13,510,508.29
Subcontracts						
	Tunnel Muck - Miscl Surface Handling	20.00	$/m3	1,469,024.82	1.00	29,380,496.35
						$ 29,380,496.35

Total Estimated Cost:	**$**	**309,241,351.93**
Per Meter:	$	20,168.35
Per m^3:	$	336.81

Estimated by PJP
Checked by ______

Tunnel Estimating [illegible]

Detailed Cost Estimate Report

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Version VANC-1.5

[illegible]

Project:	**Newfoundland Fixed Link Study**	**Project Number:**	213789
Estimate Description:	Prefeasibility Level	**Parent Estimate ID:**	V-300
Tunnel Name:	Railway Tunnel - Up Drive	**Project Phase:**	Prefeasibility Design
Construction Activity:	Excavation (Drill & Blast) & Initial Support	**Geology Type:**	Poor to Fair Sediments & Volcanics
Estimate Definition ID:	V-316	**Estimate Date:**	June 11 2004

Tunnel Characteristics

Tunnel Length:	15,333.0		m
Design Width:	6.4		m
Design Wall Height (Ave.)	6.6		m
Design Wall to Roof:	2.5		
Design Max Height :	9.1		m
Ave Tunnel Overbreak:	20.0		cm
Tunnel Face Area:	59.3	(Includes Overbreak)	m^2
Crown Perimeter:	9.6	(Includes Overbreak)	m
Wall & Crown Perimeter:	23.2	(Includes Overbreak)	m
Wall & Crown Area:	355,933	(Includes Overbreak)	m^2
Neat Tunnel Excav. Vol.:	909,246	(Includes Overbreak)	m^3
Re-Muck / Pull-Out Bays:			
Bay Length:	10.0		m
Spacing Bttn Bays:	1000.0		m
Number of Bays:	15		No
Total Length of Bays:	150.0		m
Neat Excavation Vol.:	8,895		m^3
Total Tunnel Volume:	918,141		m^3
Muck Bulking Factor:	1.6		Ratio
Bulked Tunnel Volume:	1,469,025	(Loose Muck Volume)	m^3

Primary Mucking Production Details

(Activity to remove blast muck from face to conveyor & muck cars)

Muck Volume / Blast:	313.1		m^3
Mucking Volume / Trip:	5.00		m^3
Bucket Fill Factor (%):	90.0		%
Number of Trips:	70		No
Ave. Dist. to Load:	35.0	(Ave Distance One Way)	m
Ave. Tramming Speed:	8.0		km/hr
Load, Dump, Manoever:	1.0	(Time per Trip)	Min
Face Cleanup / Blast:	15.0		Min
Mucking Time:	2.0		Hours
Mucking Rate:	155.1		m^3 / Hour

Tunnel Support Class Details

Class I - No Support:	0.0	(%)	0	(m)
Class II - Spot Bolts:	0.0	(%)	0	(m)
Class III - Crown Only:	40.0	(%)	6,133	(m)
Class IV - Full Pattern:	50.0	(%)	7,667	(m)
Class V - Steel Sets:	10.0	(%)	1,533	(m)
Total	100.0		15,333	(m)

Initial Shotcrete Support Details

Support Arc Length:	23.2		m
Thickness:	25.0		mm
Volume / Round:	2.2		m^3
Time:	0.8	(Includes Scaling & Equip Set-up)	Hours

Shift Details

Shift Arrangement:	3.0	Shifts / Day
	8.0	Hours / Shift
	7.0	Days / Week

Drill, Charge, Blast, Vent & Mucking Details

Survey Tunnel / Holes / Map:	30.0	Min / Cycle
Drilling Blast Holes:		
Hole Length:	3.9	m / Hole
Perim. Blast Hole Spacing:	0.50	m
Interior Blast Hole Spacing:	1.25	m
No. Perimeter Holes:	46	No
No. Interior Area Holes:	38.0	No
No. Blast Initiation Holes:	14	No
Number of Drillholes / Blast:	99	Blastholes / Blast
Blast Hole / Face Area Ratio:	1.67	Holes / m^2
Typical / Check Ratio:	1.56	Holes / m^2
Drill Eqpt Set-Up Time:	40	min / Set-up
Drill Penetration Rate:	0.30	m / Min
	18	m/hour
# of Drills or Booms:	3.0	No
Charging & Blasting:		
Prime & Load Rate / Hole:	2.50	min / Blasthole
Prep & Hook-up Time:	40.0	min / Set-up
Total No. Blasts / Tunnel:	4692	No
Net Blast Break Length:	3.3	m / Blast
Blast & Ventilation Time:	1.0	Hours

Pre-Excavavation Grouting Details

% Tunnel to be Grouted:	10.0	%
Tunnel Length to Grout:	1533	m
Grout Hole Length:	7.0	m
No. of Grouting Applications:	219	No
Perim. Grout Holes Spacing:	1.50	m
# Perim. Grout Holes:	15	Holes / Grout Cycle
Drilling Penetration Rate:	50	m/hour
No. of Drill Booms:	2	No
Drilling Time per Cycle:	237	Min
Grout Eqpt. Set-Up Time:	1.0	Hours / Grout Cycle
No. of Holes Grouted at Once:	2	Hoses
Grouting Injection Rate:	10	min / Drillhole
Full Grout Cycle Time:	122.7	Hours

Steel Set Installation Details

Steel Set Spacing:	1.0	m
Total No. Sets / Tunnel:	1,533	No
Ave. Installation Time / Set:	3.0	Hours
Total Installation Time:	4,600	Hours

Estimated by PJP
Checked by

Wiremesh Installation Details

Install Rate:	100		m^2 / Hour
Total Install Time:	3,924.2		Hours
Ave. Install Time:	50.2		Min
Overlap:	5		%
Net Applied Area:	355,933	(Assume Class V only)	m^2
Area with Overlap:	392,416		m^2

Final Shotcrete Support Class Details

Shotcrete Thickness:		
Classes I and II:	0	mm
Class III:	0	mm
Classes IV:	50	mm
Class V:	100	mm
Support Arc Length:		
Class I:	0.0	m
Class II:	0.0	m
Class III:	0.0	m
Class IV:	23.2	m
Class V:	23.2	m

Initial and Final Shotcrete Application Details

Net Volume:	12,458		m^3
Rebound / Waste:	15		%
Final Layer Volume:	14,326		m^3
No. of Applications:	2695	(Required Per Bench)	No
Ave. Vol. / Application:	5.3		m^3
Surface Prep Time:	10.0		Min
Total Surface Prep Time:	26,949		Min
Application Rate:	24.0		m^3 / Hour
Total Application Time:	35,816		Min
Eqpt. Setup Time:	20.0		Min
Total Setup Time:	53,898		Min
Eqpt. Remove Time:	10.0	(Required Per Application)	Min
Total Remove Time:	26,949		Min
Total Shotcreting Time:	143,611	(For Final Shotcrete Layer)	Min
Equivalent Time / Blast:	30.6		Min / Cycle

Secondary Mucking Details

Req'd during Tunneling:	No	(No if loaded directly into trucks in tunnel)	
Ave. LHD Tram Speed:	0.0		km / hour

Wick Drain Installation Details

Drain Spacing:	0.0	m
Installation Time / Row:	0.0	Hours / Drain

Average Tunneling Productivity Cycle Details

Equiv. Pre-Exc. Grouting:	5.7		Hours
Drilling:	7.8		Hours
Charging:	4.8		Hours
Blast & Venting:	1.0		Hours
Mucking:	2.0		Hours
Scaling:	0.3		Hours
Surveying / Mapping:	0.5		Hours
Initial Shotcreting:	0.8		Hours
Install Services:	0.5	(Equiv. Time Per Cycle)	Hours
Non-Productive Time:	0.5	(Travel in/out, Break)	Hours
Include Rockbolting:	Yes	(Yes / No, as part of Cycle Time)	
If yes, % of Support Rq'd:	30	(% Req'd During Cycle for Poorer Ground)	
Rockbolting:	0.3		Hours
Total Cycle Time:	24.3		Hours

Rockbolt Support Class Details

	(Bolts Per Row)	(Bolts Per m)	(Bolts Per Support Class)
Class I:	0	0.0	0
Class II:	0.0	0.0	0
Class III:	6	4.0	24,533
Class IV:	15	10.0	76,665
Class V:	0	0.0	0
Total:			101,198

Face Scaling

Scaling Time:	20.0	min / Blast

Rockbolt Installation Details

Rockbolt Length:	3.0	m
Row Spacing:	1.5	m
No. Rockbolts Required:	101,198	No.
Ave. Bolts / Round:	21.8	Bolts / Blast
Drilled Length / Round:	65	m
Total Drilling Length:	303,593	m
Drill Penetration Rate:	1.5	m / Min
# of Drills / Booms Used:	3	No.
e. Drilling Time / Round:	14.5	Min
lt Install Rate	2.0	Min / Bolt
Ave. Bolt Install Time:	43.6	Min
Drill Set-Up Time:	10.0	Min
Total Bolt Drill/Install Time:	68.1	Min

Drainhole Details

Drainhole Spacing:	3.0	m
Drainhole Length:	1.1	m
Total Area:	177,966.3	m^2
Total Drainholes:	19,774.0	# / Per Tunnel
Total Length:	21,751.4	m

Note: Activity carried out concurrent with other activities

Duration of Tunneling:

Pre-Exc. Grouting Time =	26,866.9	Hours
Drilling Time =	36,596.4	Hours
Charge, Blast, Vent Time =	27,128.5	Hours
Primary Mucking Time =	9,470.2	Hours
Scaling Time =	4,692.2	Hours
Survey / Map Time =	2,345.9	Hours
Install Steel Sets Time =	4,599.9	Hours
Initial Shotcreting Time =	3,558.4	Hours
Install Services Time =	2,345.9	Hours
Rockbolting (of % Critical) =	1,597.1	Hours
Non-Productive Time =	2,345.9	Hours
Total Time =	121,547.3	Hours
	167.0	Months
(Critical Path Tunneling Activities Only)	723.5	Weeks
	5,064.5	Days

Other Concurrent Tunneling Activities

Rockbolting (of % Not Critical) =	3,726.6	Hours
Wiremesh Installation =	3,924.2	Hours
Final Shotcreting Time =	0.5	Hours
Drilling Drainholes =	29,001.9	Hours
Secondary Mucking =	0.0	Hours
Wick Drain Installation =	0.0	Hours

Overall Advance Rate:

3.0	m / Day
179.5	m^3 / Day

Estimated by PJP
Checked by

Resource Type	Resource Name	Unit Rate	Unit	Quantity	Resource Quantity	Total
Labor						
	Miner - Shift Boss	50.68	$/hr	121,547.3	2.00	12,320,036.24
	Miner - Operator - Journeyman	47.84	$/hr	121,547.3	11.00	63,963,061.06
	Miner - Foreman	50.68	$/hr	121,547.3	3.00	18,480,054.35
	Miner - Laborer - Journeyman	47.40	$/hr	121,547.3	5.00	28,806,714.56
	Miner - Laborer - Apprentice	45.00	$/hr	121,547.3	5.00	27,348,146.73
	Tunnel Electrician - Journeyman	47.84	$/hr	121,547.3	4.00	23,259,294.93
					30.00	174,177,307.87
Plant						
	Cable - Fans & Pumps - High Voltage	120.00	$/m	15,333.0	0.20	367,992.00
	Cable - Lights / Controls - Low Voltage	10.00	$/m	15,333.0	0.80	122,664.00
	Compressor	45.61	$/wk	723.5	1.00	33,000.00
	Conveyor - Heading Muck Loading	1,788.19	$/wk	723.5	1.00	1,293,750.00
	Drill - Jack-Leg	29.03	$/wk	723.5	4.00	84,000.00
	Drill Jumbo - Rail Mounted - 2 Boom	362.82	$/wk	723.5	1.00	262,500.00
	Drill Jumbo - Rail Mounted - 3 Boom	518.32	$/wk	723.5	1.00	375,000.00
	Excavator - Rail Mounted	114.03	$/wk	723.5	1.00	82,500.00
	Generator - Back-Up - 500KW	108.85	$/wk	723.5	1.00	78,750.00
	Generator - Working - 1000KW	812.72	$/wk	723.5	1.00	588,000.00
	Grout Plant-Consol-D&B-Pump, Hoses	68.42	$/wk	723.5	1.00	49,500.00
	Lighting (Including Consumables)	7.50	$/m	15,333.0	1.00	114,997.50
	Locomotive - Diesel - 16T	5,000.00	$/wk	723.5	4.00	14,469,918.91
	LHD Loader - D&B Tunnel	347.79	$/wk	723.5	1.00	251,625.00
	Manlift / Platform - Rail Mounted	152.04	$/wk	723.5	1.00	110,000.00
	Pipe - 50mm (Water Supply)	7.50	$/m	15,333.0	1.00	114,997.50
	Pipe - 100mm (Air Supply)	15.00	$/m	15,333.0	1.00	229,995.00
	Rail - 80 lb/yd - Used	101.54	$/m	31,066.0	0.60	1,892,636.31
	Rail - California Switch Gear	75,000.00	$/Nr	1.0	3.00	225,000.00
	Rail Car - Flat	50,000.00	$/Nr	1.0	3.00	150,000.00
	Rail Car - Man Rider	50,000.00	$/Nr	1.0	1.00	50,000.00
	Rail Car - Muck Cars	1,900.00	$/Nr	723.5	18.00	24,743,561.33
	Rail Car - Muck Car Tipping System	75,000.00	$/Nr	1.0	1.00	75,000.00
	Shotcrete Machine - Rail Mounted	166.90	$/wk	723.5	1.00	120,750.00
	Shotcrete Machine - Tire Mounted	270.22	$/wk	723.5	2.00	391,000.00
	Small Tools	200.00	$/wk	723.5	1.00	144,699.19
	Tie Plates, Splice Bars, Bolts	150,000.00	LS	1.0	1.00	150,000.00
	Ties - Wooden - Untreated - 7" x 9" x 40"	23.00	$/m	15,333.0	1.00	352,659.00
	Transformers & Switchgear - High Voltag	76.02	$/wk	723.5	1.00	55,000.00
	Transformers-Switchgear-Low Voltage	38.01	$/wk	723.5	1.00	27,500.00
	Ventilation Duct - Rigid	110.00	$/m	15,333.0	1.00	1,686,630.00
	Ventilation Fans - 75HP	21.46	$/wk	723.5	7.00	108,675.00
	Welder (Plant)	2.38	$/wk	723.5	1.00	1,725.00
						48,804,025.74
Consumables						
	Bits, Powder and Caps - Blasting	15.00	$/m3	918,140.5	1.00	13,772,107.66
	Bits - (Drainholes & Rockbolts)	5.00	$/m	325,344.8	1.00	1,626,724.21
	Drill Jumbo Maintenance	100.00	$/hr	34,995.8	1.00	3,499,575.81
	Electricity - Tunnel Heading Conveyor	0.22	$/kwh	150	1,172.95	38,707.50
	Electricity - Fans & Lighting	0.22	$/kwh	437	60,773.66	5,849,350.37
	Electricity - Jumbo	0.22	$/kwh	75	34,995.76	577,430.01
	Lubricants	2,500.00	$/wk	723.5	1.00	1,808,739.86
	Fuels & Lubricants	5,000.00	$/wk	723.5	1.00	3,617,479.73
	Other Consumables	1,500.00	$/wk	723.5	1.00	1,085,243.92
						$ 31,875,359.08

Estimated by ____PJP____

Checked by __________

Resource Type	Resource Name	Unit Rate	Unit	Quantity	Resource Quantity	Total
Materials						
	Grout - Consolidation	50.00	$/m3	2,000.0	1.00	100,000.00
	Other Materials	2,000.00	$/wk	723.5	1.00	1,446,991.89
	Rock Bolts - No 10 - 3.0m - (Non-Galv)	40.00	$/Nr	101,198	1.00	4,047,912.00
	Shotcrete	180.00	$/m3	14,326.3	1.00	2,578,732.41
	Steel Sets - W10 x 65	152.75	$/m	1,533	23.21	5,436,871.99
	Synthetic Wick Drains	5.00	$/m	0	1.00	-
	WWF mesh	5.50	$/m2	392,416	1.00	2,158,286.91
						$ 13,510,508.29
Subcontracts						
	Tunnel Muck - Miscl Surface Handling	20.00	$/m3	1,469,024.82	1.00	29,380,496.35
						$ 29,380,496.35

Total Estimated Cost:	$	**297,747,697.32**
Per Meter:	$	19,418.75
Per m^3:	$	324.29

Newfoundland Fixed Link Pre-feasibility Study
Drill and Blast Rail Tunnel
Tunnel Final Liner Cost Estimate

Tunnel length= 30667 m
Liner cross section area= 13.5 m2

Shift pattern

Shifts	Hours	Days
3	8	5

Advance rate= 10 m/day

Rebar ratio= 0.12 t/m3 of concrete

Concrete supply=$ 135 /m3

Rebar supply=$ 900 /t

Initial form set-up time= 4 weeks

Durations

Number of days= 3087 days
Number of hours= 74081 hours
Number of weeks= 617 weeks

Labour

Crew size 20
Average labour rate $ 47 /hour

Total labour cost=$ 69,635,952

Equipment

Form $ 1000000
Weekly cost of other equipment $ 15000 (see TED 2370)

Total equipment cost=$ 10,260,100

Materials

Concrete= 414004.5 m3
Rebar= 49680.54

Concrete cost=$ 55,890,608
Rebar cost=$ 44,712,486

Total material cost=$ 100,603,094

Cost Summary

Labour	69,635,952
Equipment	10,260,100
Materials	100,603,094
Total	**180,499,146**

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: North Approach
Option: D&B Rail Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient	0	%	+ sloping same way as track/road - sloping against track/road
Track/Road Gradient	1.663	%	
Ground elevation at portal	100	m	
Bottom of slab elevation at portal	86.95	m	

Total length= 784.7264 m

Total Cost=$ 8.2 M

Newfoundland Fixed Link Pre-feasibility Study
Drill and Blast Rail Tunnel
Tunnel Final Liner Cost Estimate

Tunnel length= 30667 m
Liner cross section area= 13.5 m2

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Equipment	10,260,100
Materials	100,603,094
Total	**180,499,146**

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: North Approach
Option: D&B Rail Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient 0 %

+ sloping same way as track/road
- sloping against track/road

Track/Road Gradient 1.663 %

Ground elevation at portal 100 m

Bottom of slab elevation at portal 86.95 m

Total length= 784.7264 m

Total Cost=$ 8.2 M

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
D&B Rail Tunnel

UNIT RATES

Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

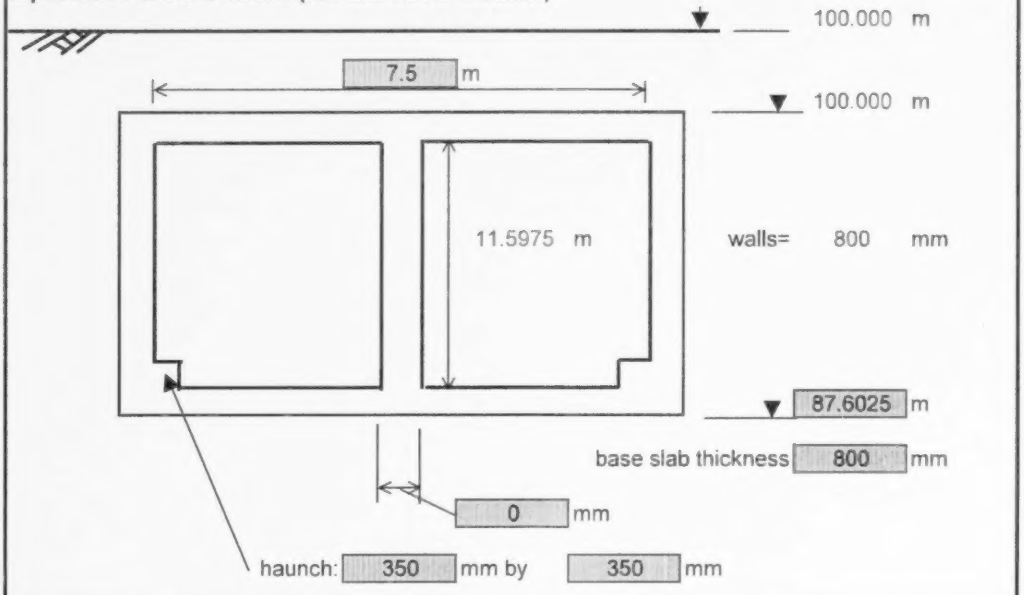
Newfoundland Fixed Link Pre-feasibility Study
North Approach
D&B Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 78.47264 m

Section 1

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
11.5975 m
walls= 800 mm
87.6025 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	8853.1	m3	
concrete=	2046.645	m3	
rebar=	245.6	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1820.173	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1945.7	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	714.101	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
D&B Rail Tunnel

UNIT RATES

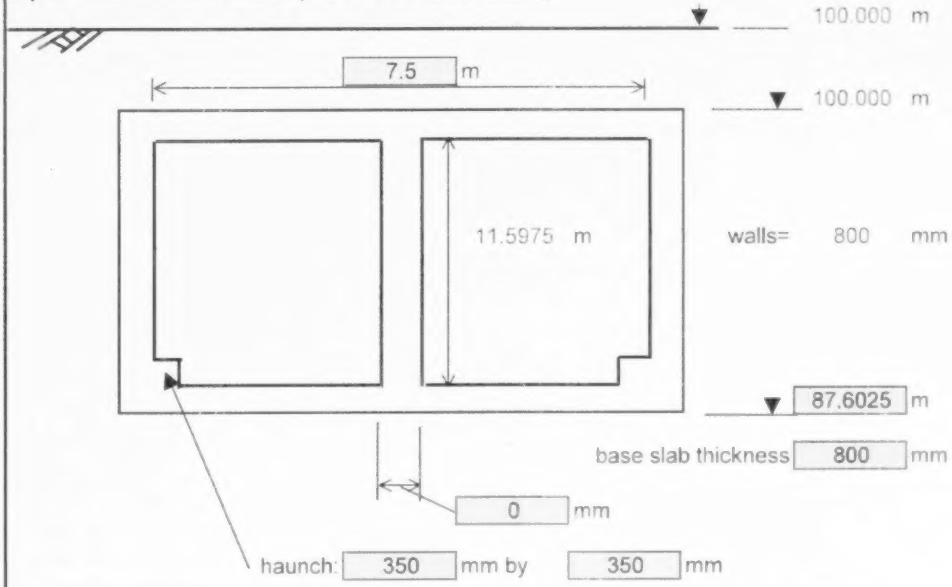
Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
D&B Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section 1**

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
11.5975 m
walls= 800 mm
87.6025 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	8853.1	m3	
concrete=	2046.645	m3	
rebar=	245.6	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1820.173	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1945.7	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	714.101	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
D&B Rail Tunnel **Page 2 of 2**

Calculated costs

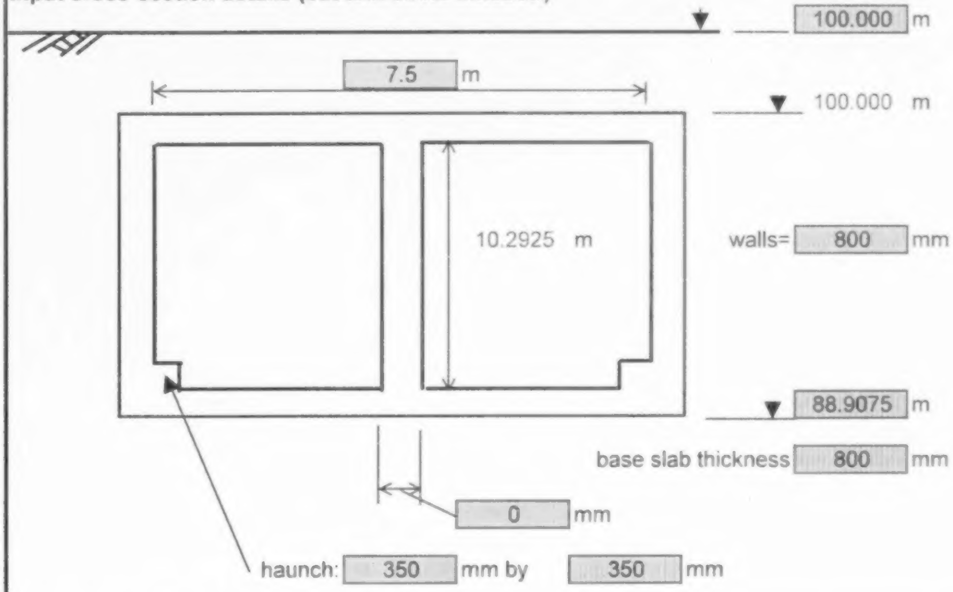
Item	Unit	Quantity	Rate	Cost
excavation	m3	8853.1	60	531184
concrete	m3	2046.645	190.0	388862.5
rebar	tonnes	245.6	1600	392955.8
formwork/falsework	m2	1820.173	140	254824.2
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	1945.7	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	714.101	30	21423.03
			Total	1589250

Newfoundland Fixed Link Pre-feasibility Study
North Approach
D&B Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 78.47264 m
Section 2

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
10.2925 m
walls= 800 mm
88.9075 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

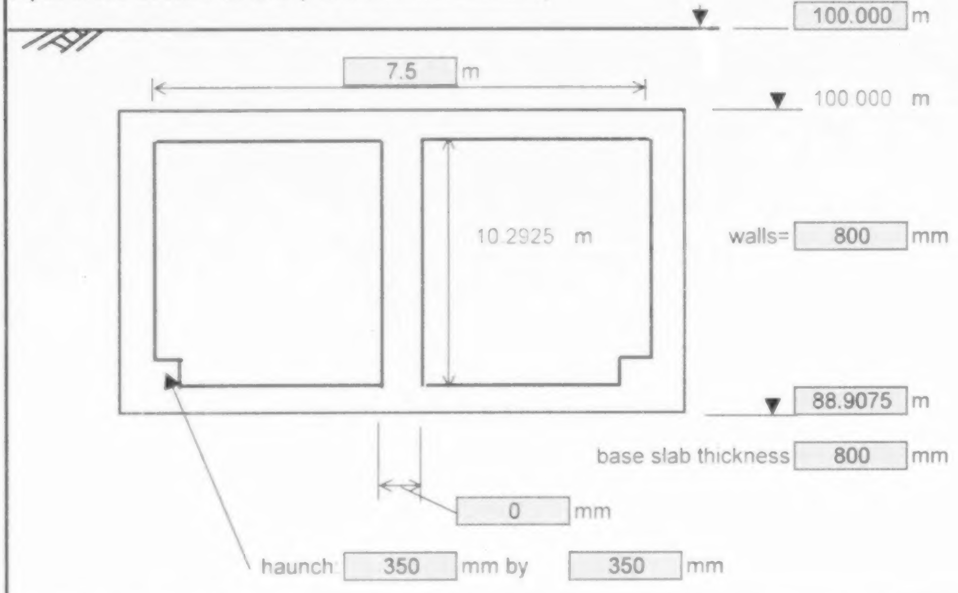
Calculated Quantities

excavation=	7921.2	m3	
concrete=	1882.794	m3	
rebar=	225.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1615.359	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1740.9	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	714.101	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
D&B Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section** 2

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
10.2925 m
walls= 800 mm
88.9075 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	7921.2	m3	
concrete=	1882.794	m3	
rebar=	225.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1615.359	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1740.9	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	714.101	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
D&B Rail Tunnel **Page 2 of 2**

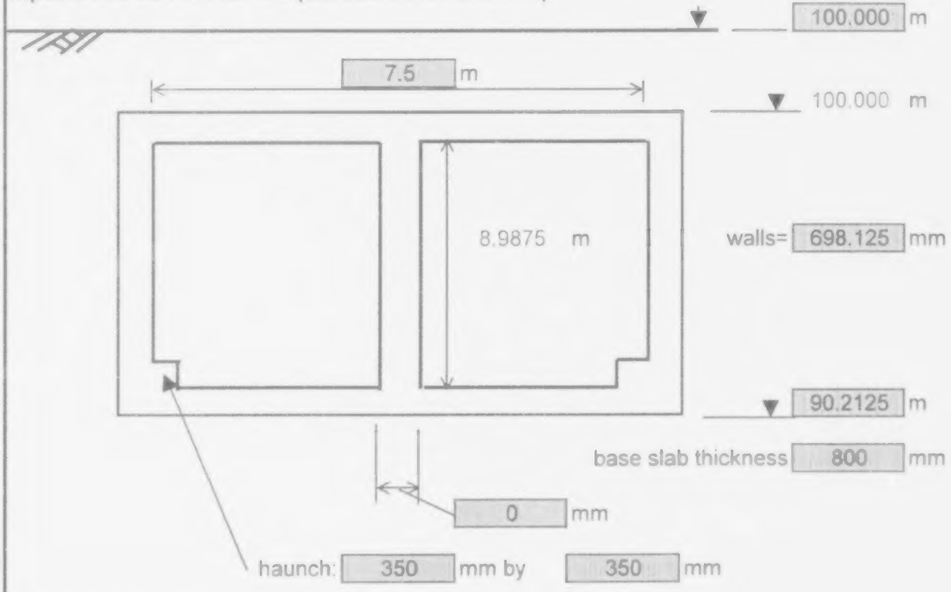
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	7921.2	60	475269.9
concrete	m3	1882.794	190.0	357730.9
rebar	tonnes	225.9	1600	361496.5
formwork/falsework	m2	1615.359	140	226150.3
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	1740.9	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	714.101	30	21423.03
			Total	1442071

Newfoundland Fixed Link Pre-feasibility Study	**Date:** 8-Jun-04
North Approach	**Calculations by:** ANW
D&B Rail Tunnel	**Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section** 3

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
8.9875 m
walls= 698.125 mm
90.2125 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

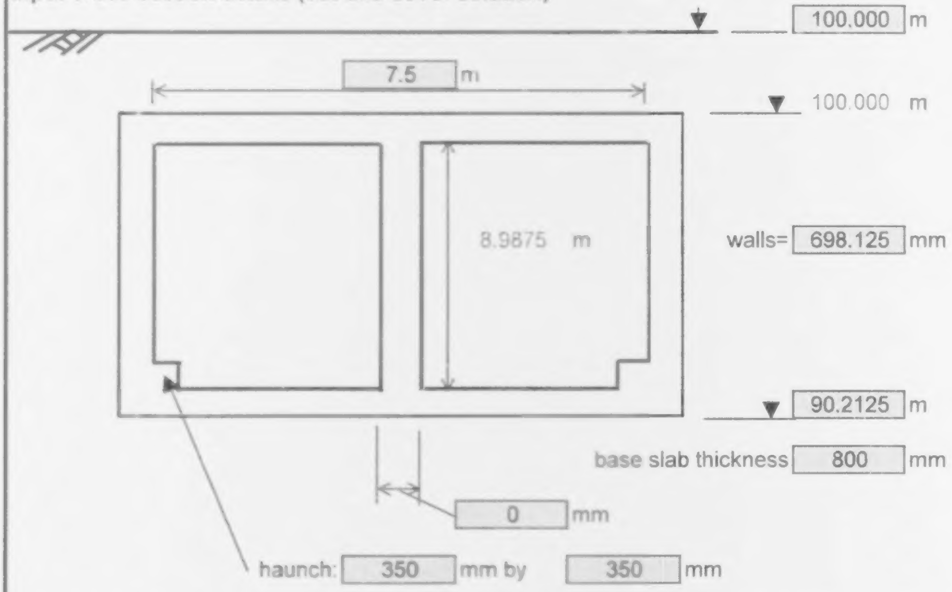
Calculated Quantities

excavation=	6832.8	m3	
concrete=	1562.453	m3	
rebar=	187.5	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1410.546	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1536.1	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	698.1122	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
North Approach **Calculations by:** ANW
D&B Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 78.47264 m **Section** **3**

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
8.9875 m
walls= 698.125 mm
90.2125 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	6832.8	m3	
concrete=	1562.453	m3	
rebar=	187.5	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1410.546	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1536.1	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	698.1122	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	6832.8	60	409966.4
concrete	m3	1562.453	190.0	296866
rebar	tonnes	187.5	1600	299990.9
formwork/falsework	m2	1410.546	140	197476.4
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1536.1	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	698.1122	30	20943.37
			Total	1225243

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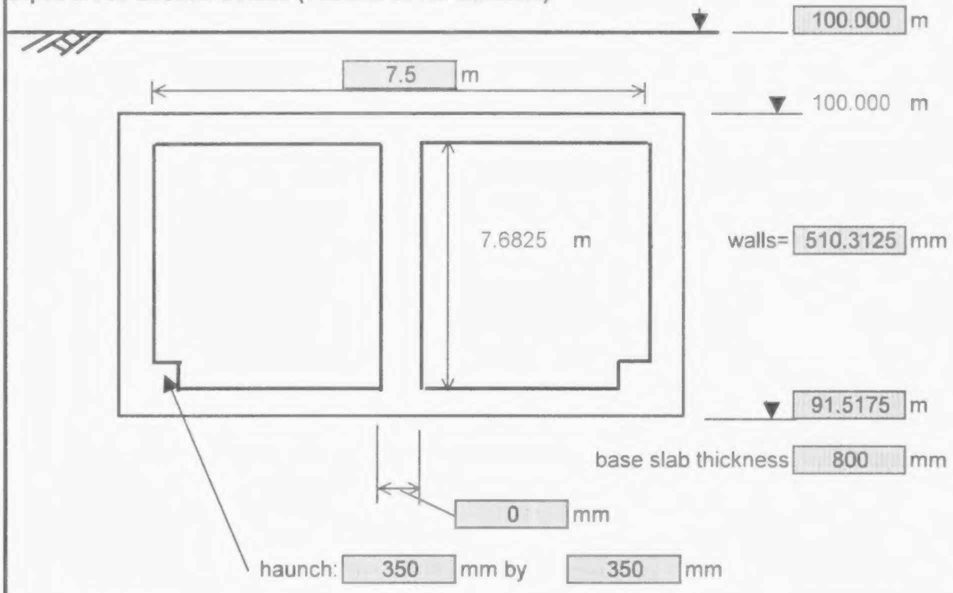
Section Cut and Cover
Length of section: 78.47264 m **Section 4**

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
7.6825 m
walls= 510.3125 mm
91.5175 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	5671.7	m3	
concrete=	1169.435	m3	
rebar=	140.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1205.732	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1331.3	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	668.6359	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	5671.7	60	340302.3
concrete	m3	1169.435	190.0	222192.6
rebar	tonnes	140.3	1600	224531.5
formwork/falsework	m2	1205.732	140	168802.5
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1331.3	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	668.6359	30	20059.08
			Total	975887.9

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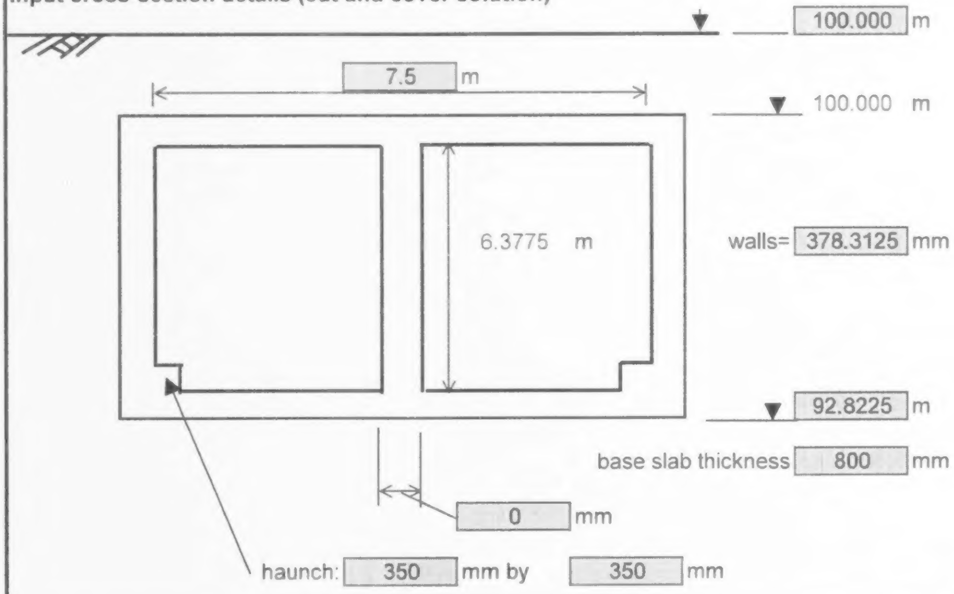
Section Cut and Cover
Length of section: 78.47264 m **Section 5**

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
6.3775 m
walls= 378.3125 mm
92.8225 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	4650.4	m3	
concrete=	916.2211	m3	
rebar=	109.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1000.919	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1126.5	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	647.9192	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	4650.4	60	279026.4
concrete	m3	916.2211	190.0	174082
rebar	tonnes	109.9	1600	175914.5
formwork/falsework	m2	1000.919	140	140128.6
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1126.5	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	647.9192	30	19437.57
			Total	788589

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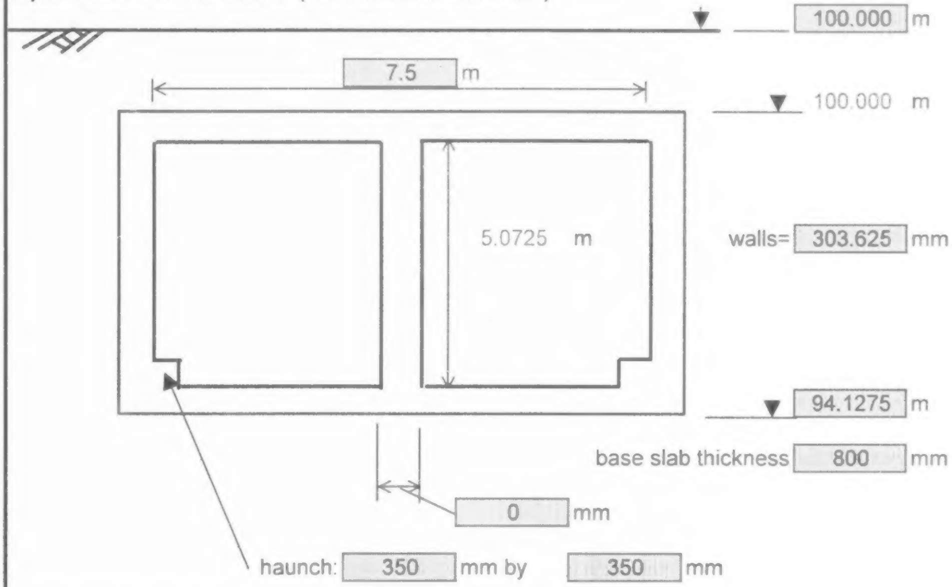
Section Cut and Cover
Length of section: 78.47264 m
Section 6

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
5.0725 m
walls= 303.625 mm
94.1275 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	3736.1	m3	
concrete=	769.901	m3	
rebar=	92.4	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	796.1049	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	921.7	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	636.1973	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	3736.1	60	224164.1
concrete	m3	769.901	190.0	146281.2
rebar	tonnes	92.4	1600	147821
formwork/falsework	m2	796.1049	140	111454.7
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	921.7	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	636.1973	30	19085.92
			Total	648806.9

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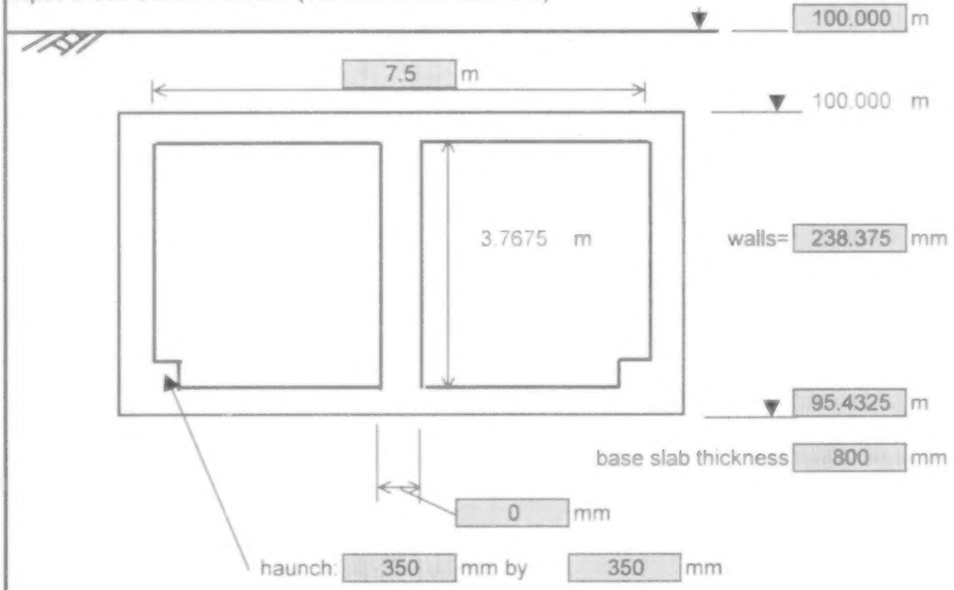
Section Cut and Cover
Length of section: 78.47264 m **Section** 7

Input cross-section details (cut and cover solution)



walls= 238.375 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	2859.1	m3	
concrete=	660.9402	m3	
rebar=	79.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	591.2913	m2	
SP&L<=4.6m deep	716.8	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	625.9566	m2	

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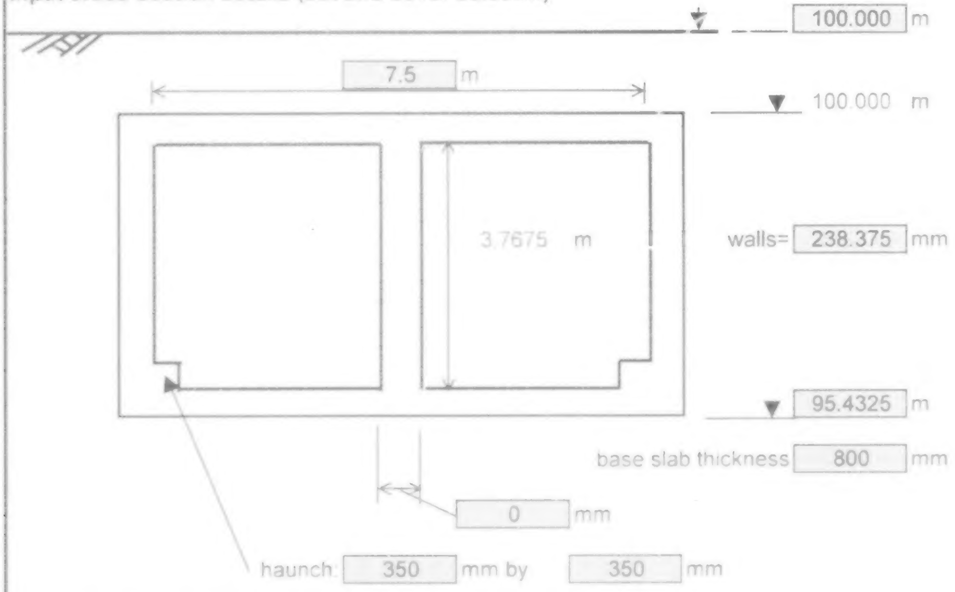
Section Cut and Cover
Length of section: 78.47264 m **Section 7**

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
3.7675 m
walls= 238.375 mm
95.4325 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	2859.1	m3	
concrete=	660.9402	m3	
rebar=	79.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	591.2913	m2	
SP&L<=4.6m deep	716.8	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	625.9566	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	2859.1	60	171543.4
concrete	m3	660.9402	190.0	125578.6
rebar	tonnes	79.3	1600	126900.5
formwork/falsework	m2	591.2913	140	82780.79
SP&L<=4.6m deep	m2	716.8	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	625.9566	30	18778.7
			Total	525582

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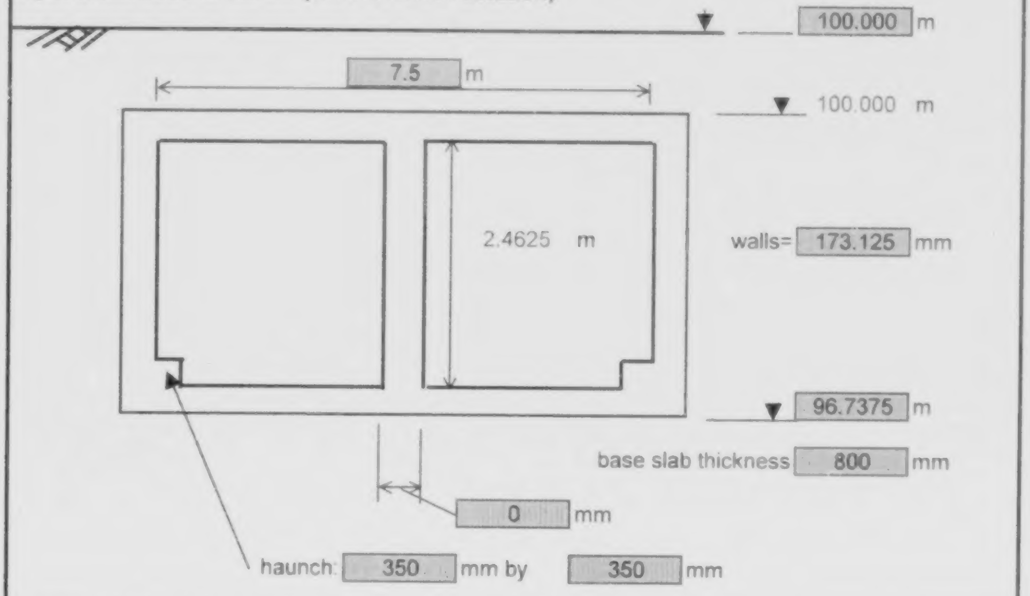
Section Cut and Cover
Length of section: 78.47264 m **Section 8**

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
2.4625 m
walls= 173.125 mm
96.7375 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	2008.8	m3	
concrete=	578.7075	m3	
rebar=	69.4	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	386.4778	m2	
SP&L<=4.6m deep	512.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	615.716	m2	

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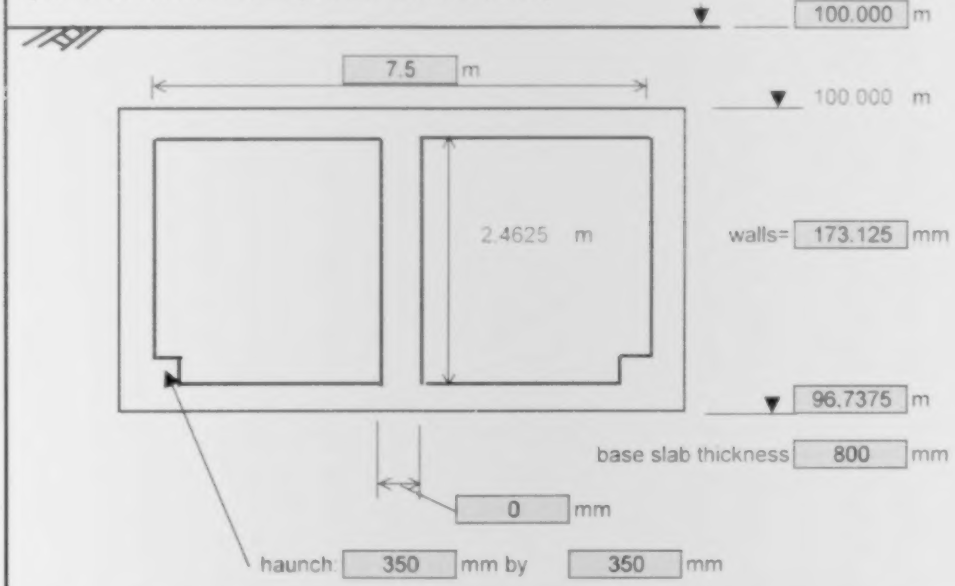
Section Cut and Cover
Length of section: 78.47264 m **Section 8**

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
2.4625 m
walls= 173.125 mm
96.7375 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	2008.8	m3
concrete=	578.7075	m3
rebar=	69.4	tonnes (assume 0.12t/m3 of concrete)
formwork/falsework=	386.4778	m2
SP&L<=4.6m deep	512.0	m2
4.6<SP&L<=6.7m deep	0.0	m2
6.7<SP&L<=10.6m deep	0.0	m2
10.6<SP&L<=13.7m deep	0.0	m2
13.7<SP&L<=16.8m deep	0.0	m2
16.8<SP&L<=20.0m deep	0.0	m2
20<SP&L<=25m deep	0.0	m2
backfill=	0	m3
surface reinstatement=	615.716	m2

Newfoundland Fixed Link Pre-feasibility Study
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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	2008.8	60	120526.4
concrete	m3	578.7075	190.0	109954.4
rebar	tonnes	69.4	1600	111111.8
formwork/falsework	m2	386.4778	140	54106.89
SP&L<=4.6m deep	m2	512.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	615.716	30	18471.48
			Total	414171

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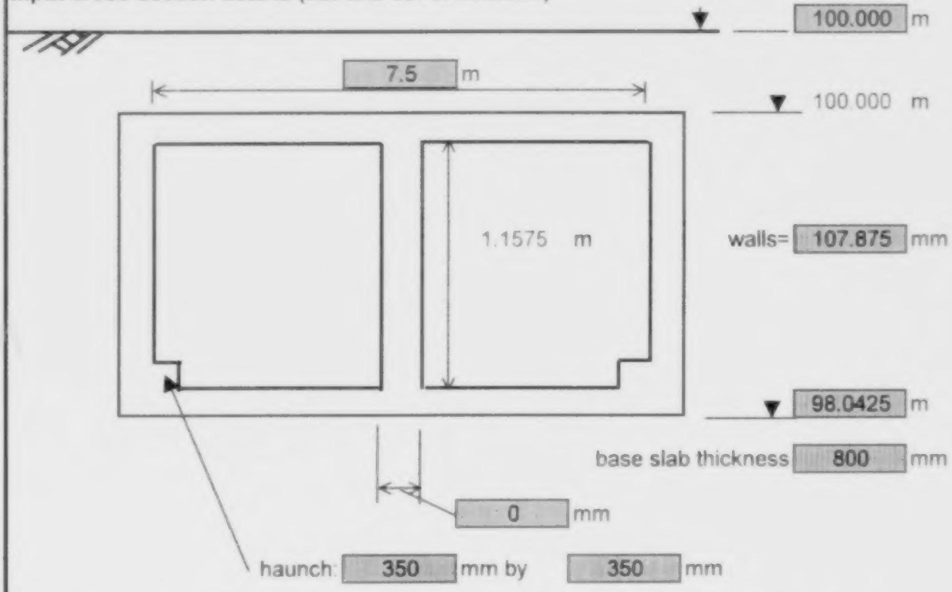
Section Cut and Cover
Length of section: 78.47264 m
Section 9

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
1.1575 m
walls= 107.875 mm
98.0425 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	1185.2	m3	
concrete=	523.203	m3	
rebar=	62.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	181.6642	m2	
SP&L<=4.6m deep	307.2	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	605.4753	m2	

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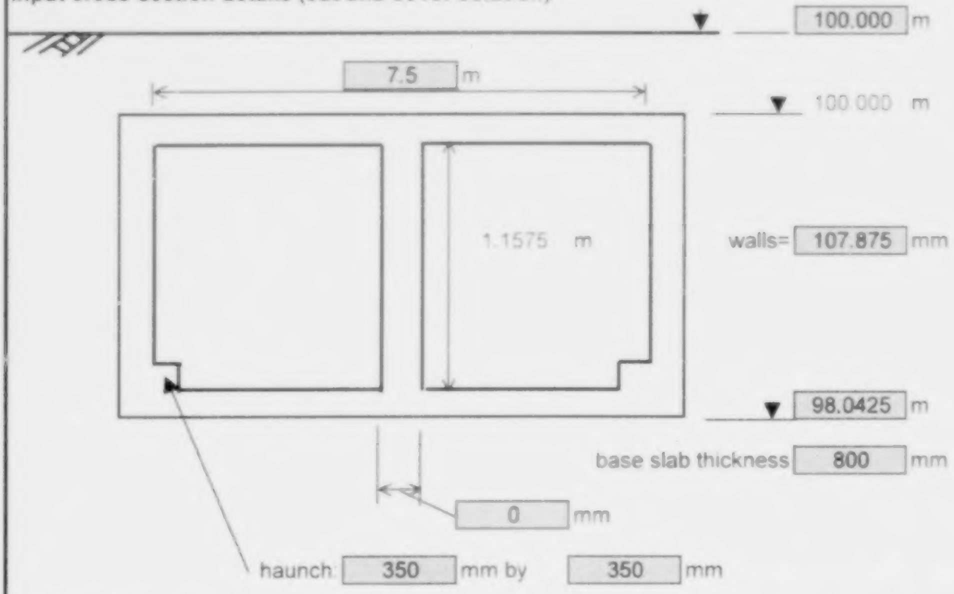
Section Cut and Cover
Length of section: 78.47264 m **Section** 9

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
1.1575 m
walls= 107.875 mm
98.0425 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	1185.2	m3	
concrete=	523.203	m3	
rebar=	62.8	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	181.6642	m2	
SP&L<=4.6m deep	307.2	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	605.4753	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	1185.2	60	71113.07
concrete	m3	523.203	190.0	99408.58
rebar	tonnes	62.8	1600	100455
formwork/falsework	m2	181.6642	140	25432.98
SP&L<=4.6m deep	m2	307.2	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	605.4753	30	18164.26
			Total	314573.9

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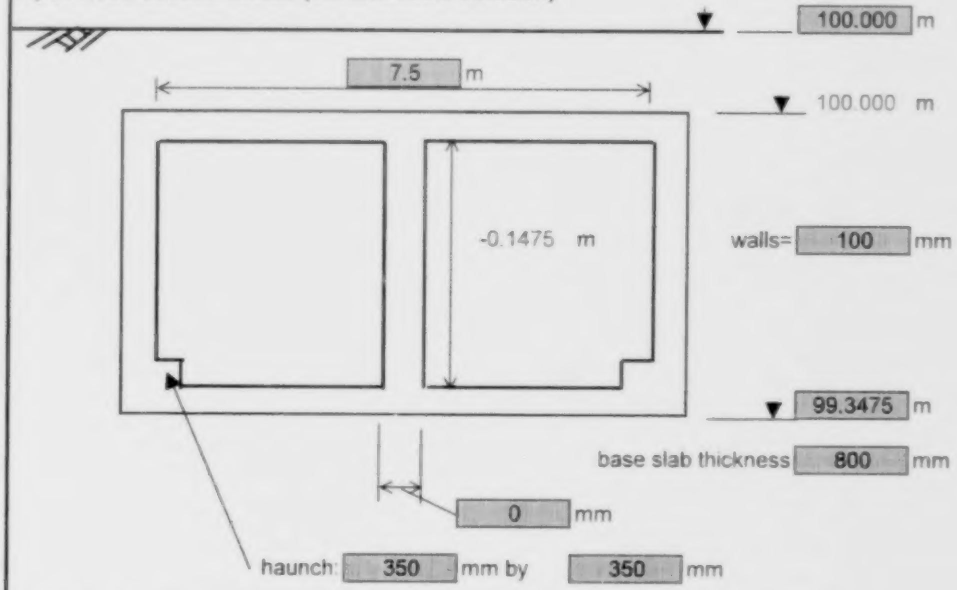
Section Cut and Cover
Length of section: 78.47264 m
Section **10**

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
-0.1475 m
walls= 100 mm
99.3475 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	394.3	m3	
concrete=	500.3023	m3	
rebar=	60.0	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	-23.14943	m2	
SP&L<=4.6m deep	102.4	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	604.2393	m2	

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Calculations by: ANW
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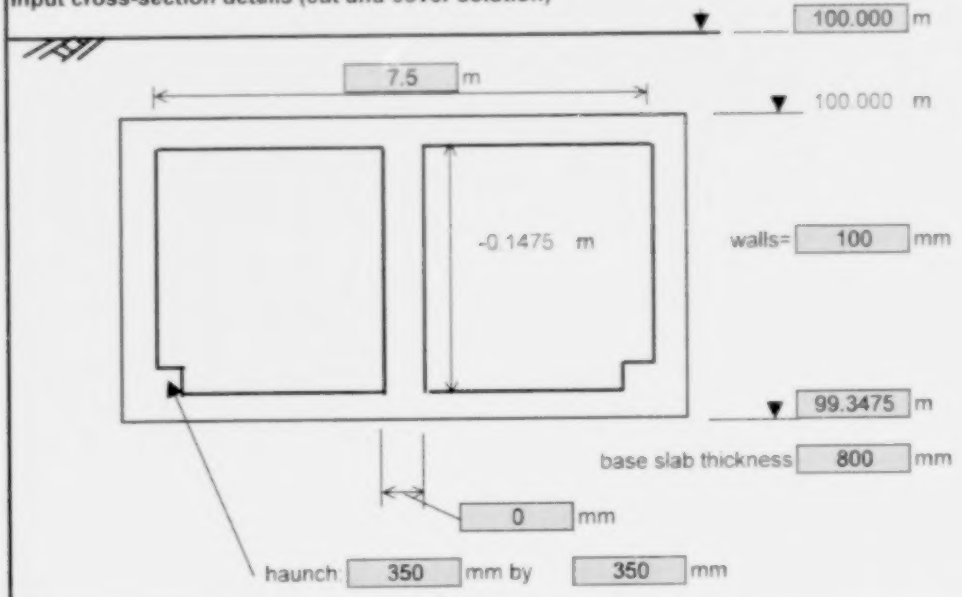
Section Cut and Cover
Length of section: 78.47264 m
Section **10**

Input cross-section details (cut and cover solution)



walls= 100 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	394.3	m3	
concrete=	500.3023	m3	
rebar=	60.0	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	-23.14943	m2	
SP&L<=4.6m deep	102.4	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	604.2393	m2	

Newfoundland Fixed Link Pre-feasibility Study
North Approach
D&B Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 2 of 2

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	394.3	60	23655.97
concrete	m3	500.3023	190.0	95057.44
rebar	tonnes	60.0	1600	96058.04
formwork/falsework	m2	-23.14943	140	-3240.92
SP&L<=4.6m deep	m2	102.4	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	604.2393	30	18127.18
			Total	229657.7

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04

North Approach **Calculations by:** ANW

D&B Rail Tunnel

Summary of Costs

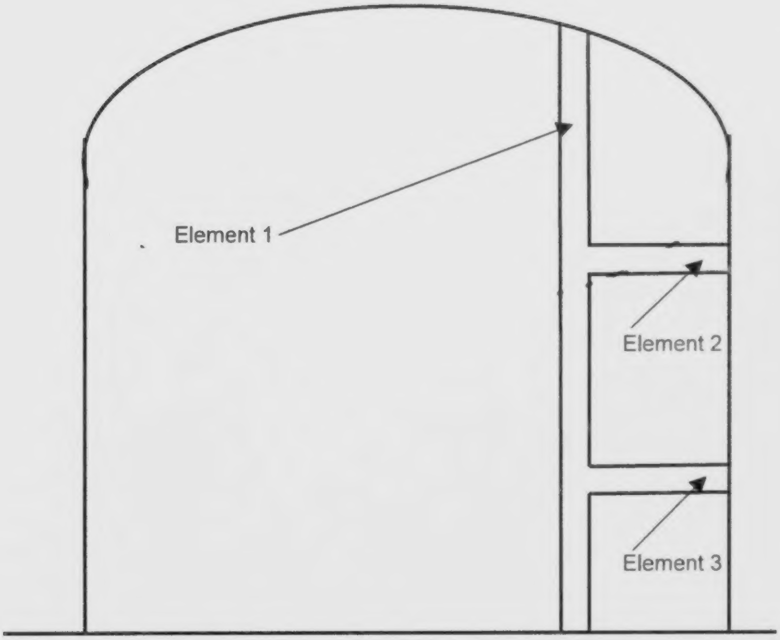
Markup for adjacent 0 %

Section	**Cost**
1	1589250
2	1442071
3	1225243
4	975887.9
5	788589
6	648806.9
7	525582
8	414171
9	314573.9
10	229657.7
Sub-total	8153832

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Drill & Blast Railway Tunnel
Tunnel Structural Finishes

Page 1 of 2
Date: June 07, 2004
Calculation by: A.White

Tunnel length= 30667 m


Element 1
Element 2
Element 3

Assumed tunnel cross section

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Drill & Blast Railway Tunnel
Tunnel Structural Finishes

Page 2 of 2
Date: June 07, 2004
Calculation by: A.White

Quantity Take-off

Concrete

Element	Nr.	L(m)	b(m)	d(m)	Concrete Qty(m3)	Rebar Qty(m3)
1	1	30667	0.3	6.9	63481	7617.7
2	1	30667	1.5	0.3	13800	1656.0
3	1	30667	1.5	0.3	13800	1656.0
4	1	30667	5.5	1.0	168669	20240.2
					259749 m3	31170 t

Formwork/falsework

Element	Nr.	L(m)	d(m)	Faces	Area(m2)
1	1	30667	6.9	2	423204.6
2	1	30667	1.5	1	46000.5
3	1	30667	1.5	1	46000.5
4	1	30667	0	0	0
					515205.6 m2

Rates

Concrete	m3	190
Formwork	m2	140
Reinforcement	t	1600

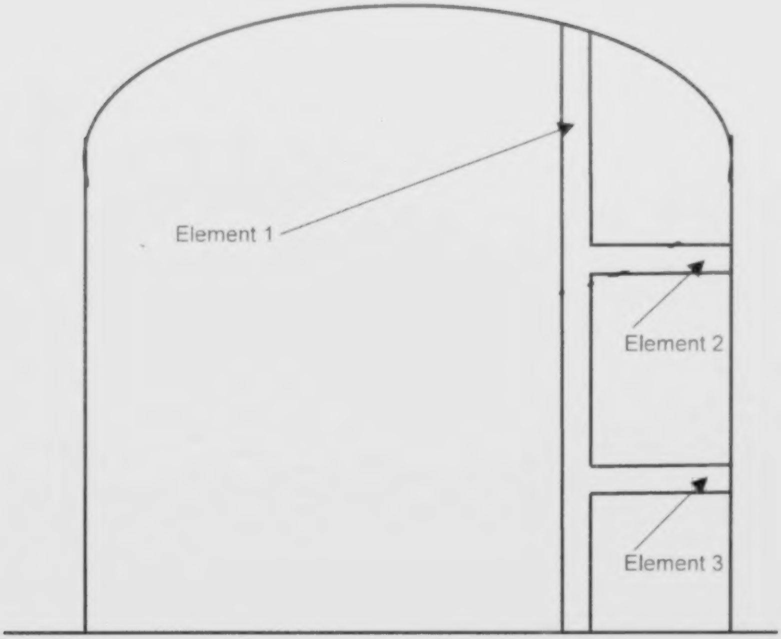
Costs

Concrete	m3	259749	m3	at	190	=	49,352,403
Formwork	m2	515206	m2	at	140	=	72,128,784
Reinforcement	t	31170	t	at	1600	=	49,871,902
						$	171,353,089

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Drill & Blast Railway Tunnel
Tunnel Structural Finishes

Page 1 of 2
Date: June 07, 2004
Calculation by: A.White

Tunnel length=	30667	m


Element 1
Element 2
Element 3

Assumed tunnel cross section

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
Drill & Blast Railway Tunnel
Tunnel Structural Finishes

Date: June 07, 2004
Calculation by: A.White

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Reinforcement	t	31170	t	at	1600	=	49,871,902
						$	171,353,089

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Newfoundland Fixed Link Pre-feasibility - Immersed Tube Railway Tunnel - Cost Summary

ITEM	UNIT	MAIN TUNNEL
MOBILIZATION & DEMOBILIZATION	LS	43,756,161
FABRICATION FACILITIES LEASE	LS	52,309,783
TUNNEL ELEMENT FABRICATION	LS	576,906,382
TUNNEL ELEMENT FINISHES	LS	49,530,184
MARINE DREDGE & BACKFILL	LS	584,140,179
UNIT TRANSPORT, PLACEMENT & CLOSURE	LS	247,961,957
NORTH TBM TUNNEL	LS	110,073,842
SOUTH D&B TUNNEL	LS	35,130,365
SOUTH APPROACH STRUCTURE	LS	6,061,178
NORTH APPROACH STRUCTURES	LS	3,531,204
RAIL TRACK	LS	13,398,500
TUNNEL DRAINAGE	LS	7,820,000
UTILITY DIVERSIONS	LS	1,000,000
MONITORING	LS	1,000,000
SUBTOTAL CIVIL		**$1,732,619,735**
CIVIL CONTINGENCIES		
CONTINGENCY	40%	$693,047,894
TOTAL CIVIL		**$2,425,667,628**
M&E, ROLLING STOCK, RAIL HARDWARE AND FINISHING WORK		
ROLLING STOCK, TERMINALS, OCS, ETC	LS	$48,000,000
VENTILATION EQUIPMENT	LS	$3,000,000
VENTILATION SHAFTS AND BUILDINGS x 2	LS	$0
FIRE SUPPRESSION SYSTEM	LS	$2,000,000
CONTROL CENTRE	LS	$1,000,000
SIGNALLING	LS	$1,000,000
LIGHTING	LS	$2,000,000
CCTV SYSTEM	LS	$0
GAS DETECTION	LS	$900,000
SUBSTATION, GENERATORS, UPS	LS	$2,000,000
SUBTOTAL M&E AND FINISHING		**$59,900,000**
CONTINGENCIES	20%	$11,980,000
TOTAL M&E AND FINISHING		**$71,880,000**
TOTAL CIVIL, M&E AND FINISHING		**$2,497,547,628**
ALLOWANCES		
CONTRACTOR OH	15%	$374,632,144
CONTRACTOR PROFIT	15%	$374,632,144
CONSTRUCTION TOTAL		**$3,247,000,000**
PRE-CONSTRUCTION AND SUPERVISION		
FEASIBILITY STUDY	LS	$11,000,000
ENVIRONMENTAL ASSESSMENT	LS	$4,000,000
DESIGN	5%	$162,350,000
CONSTRUCTION MANAGEMENT	10%	$324,700,000
OWNERS COSTS	2%	$64,940,000
PRE-CONSTRUCTION TOTAL		**$566,990,000**
GRAND TOTAL		**$3,813,990,000**

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Strait of Belle Isle Crossing

Preliminary Immersed Tube Tunnel Cost Estimate - Rail Tunnel

Item	*Unit*	*Quantity*	*Rate*	*Total*
General Details				
Tunnel Length	18,000	metres		
Tunnel Element Length	150	metres	No. Elements =	120
1 Tunnel Element Fabrication				
Miscellaneous				
Mobilisation/demobilisation @ 3% of subtotal structure cost	ls	1	$32,204,534.54	$32,204,535
Fabrication facility lease (2 facilities assumed @ 5.5 yrs each)	year	11	$3,500,000.00	$38,500,000
Concrete				
Structural grade 4,000 psi placed by pump - slab on grade	m^3	165,150	$157.32	$25,981,398
Structural grade 4,000 psi placed by pump - elevated slab	m^3	135,270	$169.62	$22,944,497
Structural grade 4,000 psi placed by pump - walls	m^3	251,100	$175.31	$44,020,341
External Protection Layer, 2,500 psi, placed by pump	m^3	22,410	$153.34	$3,436,349
Keyed control joints transverse (at 20m centres approx)	m^2	32,310	$13.25	$428,108
Keyed control joints longitudinal (2 total at base/wall junction)	m	36,000	$13.25	$477,000
Curing, sprayed membrane, internal surfaces only	m	505,800	$1.32	$667,656
Formwork				
Walls, multiple use forms	m^2	626,400	$78.92	$49,435,488
Elevated Slab, multiple use forms	m^2	113,400	$81.48	$9,239,832
Reinforcement: grade 60 high yield				
Wall & Slab reinforcing, 130 kg/m^3	tonnes	71,698	$1,501.87	$107,680,475
Bending, cutting & splicing	tonnes	71,698	$270.44	$19,389,899
Waterproofing Membrane				
Steel skin plate, A36, 8 mm thick	tonnes	30,436	$3,132.11	$95,328,117
Shear connectors, 150 mm x 12 mm, including stud welding	each	2,592,000	$0.10	$259,200
Automated Welding	m	309,240	$14.86	$4,595,306
Tunnel Joints				
Structural Steel End Frames (2/element)				
Embedded steel beams, 180 kg/m	tonnes	1,542	$2,709.04	$4,177,340
Front plates, 20 mm thick	tonnes	677	$3,132.11	$2,119,812
Gina fabrication, installation	each	120	$18,524.00	$2,222,880
Omega fabrication, installation & testing	each	120	$23,335.00	$2,800,200
Joint concrete, shear keys, cover plates etc.	each	120	$20,000.00	$2,400,000
			Page Total	***$468,308,432***

Strait of Belle Isle Crossing

Preliminary Immersed Tube Tunnel Cost Estimate - Rail Tunnel

Item	*Unit*	*Quantity*	*Rate*	*Total*
			Total Brought Forward	***$468,308,432***
Temporary Works Items (Per Element)				
Structural Steel Bulkheads (2/element)				
CO Support Columns, 250 kg/m	tonnes	1,920	$2,709.04	$5,201,357
ON Skin plate, 12 mm thick	tonnes	1,440	$3,132.11	$4,510,238
FE Shear connectors, 150 mm x 12 mm, including stud welding	1.1E+07	360	$3,174.03	$1,142,651
EN Automated Welding	4000000	120	$3,174.03	$380,884
DE 5%	#######	53,880	$14.86	$800,657
CO 10%	#######	53,880	$40.06	$2,158,433
OV 2%	#######			
	tonnes	600	$3,132.11	$1,879,266
PRE-CONSTRUCTION TOTAL	#######			
	tonnes	2,640	$2,709.04	$7,151,866
GRAND TOTAL	**#######**	**42,768**	$60.40	$2,583,187
Membrane liner	m^2	42,768	$27.84	$1,190,661
2 *Tunnel Transport & Placement*				
Element Transport: tug rental etc.	each	120	$500,000.00	$60,000,000
Element placement: barge/pontoons,divers, survey etc.	each	120	$1,000,000.00	$120,000,000
Tunnel Closure				
Underwater joint completion	each	1	$2,500,000.00	$2,500,000
3 *Internal Structural & Civil Finish Works*				
Ballast				
Track ballast concrete, 2,500 psi, placed by chute	m3	54,000	$140.06	$7,563,240
Track ballast reinforcement: welded wire fabric 6 x 6 x #4, 2.8kg/m^2	m^2	81,000	$9.36	$758,160
Deduct in excess of 4.5 tonnes	tonne	222	-$41.01	-$9,104
Emergency corridor sand/cement mix for HVDC cables	m3	20,250	$140.06	$2,836,215
Precast Divider for Emergency Egress Corridor				
Panel fabrication, 8" thick, incuding reinformcement & lifting points	m^2	103,500	$196.98	$20,387,430
Panel setting, based upon max panel weight of 6 tons.	each	9,000	$285.70	$2,571,300
Seal and caulk panels	m	36,000	$5.48	$197,280
Sprayed fireproofing for precast panels	m^2	103,500	$20.77	$2,149,695
			Page Total	***$714,261,847***

Item	*Unit*	*Quantity*	*Rate*	*Total*
			Total Brought Forward	***$714,261,847***
4 *Marine Operation*				
Dredging				
Mobilization/Demobilzation per season, 6 seasons, 2 vessels	each	24	$150,000.00	$3,600,000
Stage 1 bulk dredging of material	m3	4,028,049	$84.00	$338,356,116
Stage 2 fine tolerance dredging & additional trench cleaning	m3	604,207	$43.00	$25,980,901
Foundation and Backfill				
Screeded gravel foundation	m3	157,275	$35.00	$5,504,625
Selected locking fill	m3	377,496	$35.00	$13,212,360
Backfill	m3	550,368	$35.00	$19,262,880
Rock armor protection	m3	470,790	$51.00	$24,010,290
Subtotal Structure Cost				***$1,144,189,019***
Tunnel MEP Systems	ls	10 % of structure cost		$114,418,902
Rail Systems	ls	15 % of structure cost		$171,628,353
Contingency on Tunnel Costs	ls	30% of subtotal structure cost		$343,256,706
"Soft" Costs				
Engineers design & construction supervision fee	ls	10% of construction cost		$177,349,298
Estimated Construction Cost				***$1,950,842,278***
Estimated Construction Cost per linear metre				***$108,380***

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Detailed Cost Estimate Report

[illegible]

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Version VANC-1.5

Project:	**Newfoundland Fixed Link Study**	**Project Number:**	213789
Estimate Description:	Prefeasibility Level	**Parent Estimate ID:**	V-300
Tunnel Name:	North Drill & Blast Approach	**Project Phase:**	Prefeasibility Design
Construction Activity:	Excavation (Drill & Blast) & Initial Support	**Geology Type:**	Poor to Fair Sediments & Volcanics
Estimate Definition ID:	V-315	**Estimate Date:**	June 11 2004

Tunnel Characteristics

Tunnel Length:	**6,550.0**		m
Design Width:	**6.4**		m
Design Wall Height (Ave.)	**6.6**		m
Design Wall to Roof:	**2.5**		
Design Max Height :	9.1		m
Ave Tunnel Overbreak:	**20.0**		cm
Tunnel Face Area:	59.3	(Includes Overbreak)	m^2
Crown Perimeter:	9.6	(Includes Overbreak)	m
Wall & Crown Perimeter:	23.2	(Includes Overbreak)	m
Wall & Crown Area:	152,048	(Includes Overbreak)	m^2
Neat Tunnel Excav. Vol.:	388,414	(Includes Overbreak)	m^3
Re-Muck / Pull-Out Bays:			
Bay Length:	**10.0**		m
Spacing Bttn Bays:	**1000.0**		m
Number of Bays:	6		No
Total Length of Bays:	60.0		m
Neat Excavation Vol.:	3,558		m^3
Total Tunnel Volume:	391,972		m^3
Muck Bulking Factor:	**1.6**		Ratio
Bulked Tunnel Volume:	627,156	(Loose Muck Volume)	m^3

Primary Mucking Production Details

(Activity to remove blast muck from face to conveyor & muck cars)

Muck Volume / Blast:	313.1		m^3
Mucking Volume / Trip:	**5.00**		m^3
Bucket Fill Factor (%):	**90.0**		%
Number of Trips:	70		No
Ave. Dist. to Load:	**35.0**	(Ave Distance One Way)	m
Ave. Tramming Speed:	**8.0**		km/hr
Load, Dump, Manoever:	**1.0**	(Time per Trip)	Min
Face Cleanup / Blast:	**15.0**		Min
Mucking Time:	2.0		Hours
Mucking Rate:	155.1		m^3 / Hour

Tunnel Support Class Details

Class I - No Support:	**0.0**	(%)	0	(m)
Class II - Spot Bolts:	**0.0**	(%)	0	(m)
Class III - Crown Only:	**40.0**	(%)	2,620	(m)
Class IV - Full Pattern:	**50.0**	(%)	3,275	(m)
Class V - Steel Sets:	**10.0**	(%)	655	(m)
Total	100.0		6,550	(m)

Initial Shotcrete Support Details

Support Arc Length:	**23.2**	m
Thickness:	**25.0**	mm
Volume / Round:	2.2	m^3

Shift Details

Shift Arrangement:	**3.0**	Shifts / Day
	8.0	Hours / Shift
	5.0	Days / Week

Drill, Charge, Blast, Vent & Mucking Details

Survey Tunnel / Holes / Map:	**30.0**	Min / Cycle
Drilling Blast Holes:		
Hole Length:	**3.9**	m / Hole
Perim. Blast Hole Spacing:	**0.50**	m
Interior Blast Hole Spacing:	**1.25**	m
No. Perimeter Holes:	46	No
No. Interior Area Holes:	38.0	No
No. Blast Initiation Holes:	14	No
Number of Drillholes / Blast:	99	Blastholes / Blast
Blast Hole / Face Area Ratio:	1.67	Holes / m^2
Typical / Check Ratio:	1.56	Holes / m^2
Drill Eqpt Set-Up Time:	**20**	min / Set-up
Drill Penetration Rate:	**1.50**	m / Min
	90	m/hour
# of Drills or Booms:	**3.0**	No
Charging & Blasting:		
Prime & Load Rate / Hole:	**1.25**	min / Blasthole
Prep & Hook-up Time:	**20.0**	min / Set-up
Total No. Blasts / Tunnel:	2003	No
Net Blast Break Length:	**3.3**	m / Blast
Blast & Ventilation Time:	**0.5**	Hours

Pre-Excavation Grouting Details

% Tunnel to be Grouted:	**5.0**	%
Tunnel Length to Grout:	328	m
Grout Hole Length:	**7.0**	m
No. of Grouting Applications:	47	No
Perim. Grout Holes Spacing:	**1.50**	m
# Perim. Grout Holes:	15	Holes / Grout Cycle
Drilling Penetration Rate:	**50**	m/hour
No. of Drill Booms:	**2**	No
Drilling Time per Cycle:	51	Min
Grout Eqpt. Set-Up Time:	**1.0**	Hours / Grout Cycle
No. of Holes Grouted at Once:	**2**	Hoses
Grouting Injection Rate:	**10**	min / Drillhole
Full Grout Cycle Time:	26.4	Hours

Steel Set Installation Details

Steel Set Spacing:	**1.0**	m
Total No. Sets / Tunnel:	655	No
Ave. Installation Time / Set:	**3.0**	Hours

Estimated by _____PJP_____
Checked by ______________

Time:	0.8	(Includes Scaling & Equip Set-up)	Hours	**Total Installation Time:**	1,965	Hours

Wiremesh Installation Details

Install Rate:	100	m^2 / Hour
Total Install Time:	1,676.3	Hours
Ave. Install Time:	50.2	Min
Overlap:	5	%
Net Applied Area:	152,048 (Assume Class V only)	m^2
Area with Overlap:	167,633	m^2

Final Shotcrete Support Class Details

Shotcrete Thickness:		
Classes I and II:	0	mm
Class III:	0	mm
Classes IV:	50	mm
Class V:	100	mm
Support Arc Length:		
Class I:	0.0	m
Class II:	0.0	m
Class III:	0.0	m
Class IV:	23.2	m
Class V:	23.2	m

Initial and Final Shotcrete Application Details

Net Volume:	5,322		m^3
Rebound / Waste:	15		%
Final Layer Volume:	6,120		m^3
No. of Applications:	1151	(Required Per Bench)	No
Ave. Vol. / Application:	5.3		m^3
Surface Prep Time:	10.0		Min
Total Surface Prep Time:	11,512		Min
Application Rate:	24.0		m^3 / Hour
Total Application Time:	15,300		Min
Eqpt. Setup Time:	20.0		Min
Total Setup Time:	23,024		Min
Eqpt. Remove Time:	10.0	(Required Per Application)	Min
Total Remove Time:	11,512		Min
Total Shotcreting Time:	61,348	(For Final Shotcrete Layer)	Min
Equivalent Time / Blast:	30.6		Min / Cycle

Secondary Mucking Details

Req'd during Tunneling:	No	(No if loaded directly into trucks in tunnel)	
Ave. LHD Tram Speed:	0.0		km / hour

Wick Drain Installation Details

Drain Spacing:	0.0	m
Installation Time / Row:	0.0	Hours / Drain

Average Tunneling Productivity Cycle Details

Equiv. Pre-Exc. Grouting:	0.6		Hours
Drilling:	1.8		Hours
Charging:	2.4		Hours
Blast & Venting:	0.5		Hours
Mucking:	2.0		Hours
Scaling:	0.3		Hours
Surveying / Mapping:	0.5		Hours
Initial Shotcreting:	0.8		Hours
Install Services:	0.5	(Equiv. Time Per Cycle)	Hours
Non-Productive Time:	0.5	(Travel in/out, Break)	Hours
Include Rockbolting:	Yes	(Yes / No, as part of Cycle Time)	
If yes, % of Support Rq'd:	30	(% Req'd During Cycle for Poorer Ground)	
Rockbolting:	0.3		Hours
Total Cycle Time:	10.2		Hours

Rockbolt Support Class Details

	(Bolts Per Row)	(Bolts Per m)	(Bolts Per Support Class)
Class I:	0	0.0	0
Class II:	0.0	0.0	0
Class III:	6	4.0	10,480
Class IV:	15	10.0	32,750
Class V:	0	0.0	0
Total:			43,230

Face Scaling

Scaling Time:	20.0	min / Blast

Rockbolt Installation Details

Rockbolt Length:	3.0	m
Row Spacing:	1.5	m
No. Rockbolts Required:	43,230	No
Ave. Bolts / Round:	21.8	Bolts / Blast
Drilled Length / Round:	65	m
Total Drilling Length:	129,690	m
Drill Penetration Rate:	1.5	m / Min
# of Drills / Booms Used:	3	No
Ave. Drilling Time / Round:	14.5	Min
Bolt Install Rate	2.0	Min / Bolt
Ave. Bolt Install Time:	43.6	Min
Drill Set-Up Time:	10.0	Min
Total Bolt Drill/Install Time:	68.1	Min

Drainhole Details

Drainhole Spacing:	3.0	m
Drainhole Length:	1.1	m
Total Area:	76,024.2	m^2
Total Drainholes:	8,447.1	# / Per Tunnel
Total Length:	9,291.9	m

Note: Activity carried out concurrent with other activities

Duration of Tunneling:

Pre-Exc. Grouting Time =	1,233.4	Hours
Drilling Time =	3,525.4	Hours
Charge, Blast, Vent Time =	5,790.8	Hours
Primary Mucking Time =	4,043.0	Hours
Scaling Time =	2,003.4	Hours
Survey / Map Time =	1,001.5	Hours
Install Steel Sets Time =	1,965.0	Hours
Initial Shotcreting Time =	1,519.2	Hours
Install Services Time =	1,001.5	Hours
Rockbolting (of % Critical) =	681.8	Hours
Non-Productive Time =	1,001.5	Hours
Total Time =	23,766.5	Hours
	45.7	Months
(Critical Path Tunneling Activities Only)	198.1	Weeks
	990.3	Days

Other Concurrent Tunneling Activities

Rockbolting (of % Not Critical) =	1,590.9	Hours
Wiremesh Installation =	1,676.3	Hours
Final Shotcreting Time =	0.5	Hours
Drilling Drainholes =	2,477.8	Hours
Secondary Mucking =	0.0	Hours
Wick Drain Installation =	0.0	Hours

Overall Advance Rate:

6.6	m / Day
392.2	m^3 / Day

Estimated by PJP
Checked by

Resource Type	Resource Name	Unit Rate	Unit	Quantity	Resource Quantity	Total
Labor						
	Miner - Shift Boss	50.68	$/hr	23,766.5	2.00	2,408,975.63
	Miner - Operator - Journeyman	47.84	$/hr	23,766.5	11.00	12,506,899.54
	Miner - Foreman	50.68	$/hr	23,766.5	3.00	3,613,463.45
	Miner - Laborer - Journeyman	47.40	$/hr	23,766.5	5.00	5,632,667.97
	Miner - Laborer - Apprentice	45.00	$/hr	23,766.5	5.00	5,347,469.59
	Tunnel Electrician - Journeyman	47.84	$/hr	23,766.5	4.00	4,547,963.47
					30.00	34,057,439.64
Plant						
	Cable - Fans & Pumps - High Voltage	120.00	$/m	6,550.0	0.20	157,200.00
	Cable - Lights / Controls - Low Voltage	10.00	$/m	6,550.0	0.80	52,400.00
	Compressor	166.62	$/wk	198.1	1.00	33,000.00
	Conveyor - Heading Muck Loading	6,532.30	$/wk	198.1	1.00	1,293,750.00
	Drill - Jack-Leg	106.03	$/wk	198.1	4.00	84,000.00
	Drill Jumbo - Rail Mounted - 2 Boom	1,325.39	$/wk	198.1	1.00	262,500.00
	Drill Jumbo - Rail Mounted - 3 Boom	1,893.42	$/wk	198.1	1.00	375,000.00
	Excavator - Rail Mounted	416.55	$/wk	198.1	1.00	82,500.00
	Generator - Back-Up - 500KW	397.62	$/wk	198.1	1.00	78,750.00
	Generator - Working - 1000KW	2,968.88	$/wk	198.1	1.00	588,000.00
	Grout Plant-Consol-D&B-Pump, Hoses	249.93	$/wk	198.1	1.00	49,500.00
	Lighting (Including Consumables)	7.50	$/m	6,550.0	1.00	49,125.00
	Locomotive - Diesel - 16T	591.50	$/wk	198.1	4.00	468,600.00
	LHD Loader - D&B Tunnel	1,270.48	$/wk	198.1	1.00	251,625.00
	Manlift / Platform - Rail Mounted	555.40	$/wk	198.1	1.00	110,000.00
	Pipe - 50mm (Water Supply)	7.50	$/m	6,550.0	1.00	49,125.00
	Pipe - 100mm (Air Supply)	15.00	$/m	6,550.0	1.00	98,250.00
	Pipe - 150mm (DeWatering)	25.00	$/m	3,275.0	1.00	81,875.00
	Pipe - 250mm (Dewater)	70.00	$/m	3,275.0	1.00	229,250.00
	Pipe - Dewatering Clamps (<=200mm)	7.00	$/m	6,550.0	1.00	45,850.00
	Pumps - Dewatering - Tunnel - 50HP	127.46	$/wk	99.0	15.00	189,337.50
	Rail - 80 lb/yd - Used	101.54	$/m	13,500.0	0.60	822,461.54
	Rail - California Switch Gear	75,000.00	$/Nr	1.0	3.00	225,000.00
	Rail Car - Flat	50,000.00	$/Nr	1.0	3.00	150,000.00
	Rail Car - Man Rider	50,000.00	$/Nr	1.0	1.00	50,000.00
	Rail Car - Muck Cars	25,000.00	$/Nr	1.0	18.00	450,000.00
	Rail Car - Muck Car Tipping System	75,000.00	$/Nr	1.0	1.00	75,000.00
	Shotcrete Machine - Rail Mounted	609.68	$/wk	198.1	1.00	120,750.00
	Shotcrete Machine - Tire Mounted	987.10	$/wk	198.1	2.00	391,000.00
	Small Tools	200.00	$/wk	198.1	1.00	39,610.89
	Tie Plates, Splice Bars, Bolts	150,000.00	LS	1.0	1.00	150,000.00
	Ties - Wooden - Untreated - 7" x 9" x 40"	23.00	$/m	6,550.0	1.00	150,650.00
	Transformers & Switchgear - High Voltag	277.70	$/wk	198.1	1.00	55,000.00
	Transformers-Switchgear-Low Voltage	138.85	$/wk	198.1	1.00	27,500.00
	Ventilation Duct - Rigid	110.00	$/m	6,550.0	1.00	720,500.00
	Ventilation Fans - 75HP	78.39	$/wk	198.1	7.00	108,675.00
	Welder (Plant)	8.71	$/wk	198.1	1.00	1,725.00
						8,167,509.92

Estimated by PJP
Checked by

Resource Type	Resource Name	Unit Rate	Unit	Quantity	Resource Quantity	Total
Consumables						
	Bits, Powder and Caps - Blasting	15.00	$/m3	391,972.4	1.00	5,879,586.10
	Bits - (Drainholes & Rockbolts)	5.00	$/m	138,981.9	1.00	694,909.25
	Drill Jumbo Maintenance	100.00	$/hr	3,372.4	1.00	337,242.39
	Electricity - Tunnel Heading Conveyor	0.22	$/kwh	150	500.76	16,525.00
	Electricity - Fans & Lighting	0.22	$/kwh	411	11,883.27	1,074,857.29
	Electricity - Jumbo	0.22	$/kwh	75	3,372.42	55,644.99
	Electricity - Pumps Dewatering	0.22	$/kwh	559	16,636.57	2,046,971.87
	Lubricants	2,500.00	$/wk	198.1	1.00	495,136.07
	Fuels & Lubricants	5,000.00	$/wk	198.1	1.00	990,272.15
	Other Consumables	1,500.00	$/wk	198.1	1.00	297,081.64
						$ 11,888,226.76
Materials						
	Grout - Consolidation	50.00	$/m3	2,000.0	1.00	100,000.00
	Other Materials	2,000.00	$/wk	198.1	1.00	396,108.86
	Rock Bolts - No 10 - 3.0m - (Non-Galv)	40.00	$/Nr	43,230	1.00	1,729,200.00
	Shotcrete	180.00	$/m3	6,120.0	1.00	1,101,591.16
	Steel Sets - W10 x 65	152.75	$/m	655	23.21	2,322,540.37
	Synthetic Wick Drains	5.00	$/m	0	1.00	-
	WWF mesh	5.50	$/m2	167,633	1.00	921,983.91
						$ 5,549,440.39
Subcontracts						
	Tunnel Muck - Miscl Surface Handling	20.00	$/m3	627,155.85	1.00	12,543,117.02
						$ 12,543,117.02
					Total Estimated Cost:	**$ 72,205,733.74**
					Per Meter:	$ 11,023.78
					Per m^3:	$ 184.21

Newfoundland Fixed Link Pre-feasibility Study
Immersed Tube Rail Option **North D&B Approach Final Liner**
Tunnel Final Liner Cost Estimate

Tunnel length= 6535 m
Liner cross section area= 13.5 m2

Shift pattern

Shifts	Hours	Days
3	8	5

Advance rate= 10 m/day

Rebar ratio= 0.12 t/m3 of concrete

Concrete supply=$ 135 /m3

Rebar supply=$ 900 /t

Initial form set-up time= 4 weeks

Durations

Number of days= 674 days
Number of hours= 16164 hours
Number of weeks= 135 weeks

Labour

Crew size 20
Average labour rate $ 47 /hour

Total labour cost=$ 15,194,160

Equipment

Form $ 1000000
Weekly cost of other equipment $ 15000 (see TED 2370)

Total equipment cost=$ 3,020,500

Materials

Concrete= 88222.5 m3
Rebar= 10586.7

Concrete cost=$ 11,910,038
Rebar cost=$ 9,528,030

Total material cost=$ 21,438,068

Cost Summary

Labour	15,194,160
Equipment	3,020,500
Materials	21,438,068
Total	**39,652,728**

Newfoundland Fixed Link Pre-feasibility Study
Immersed Tube Rail Option **North D&B Approach Final Liner**
Tunnel Final Liner Cost Estimate

Tunnel length= 6535 m
Liner cross section area= 13.5 m2

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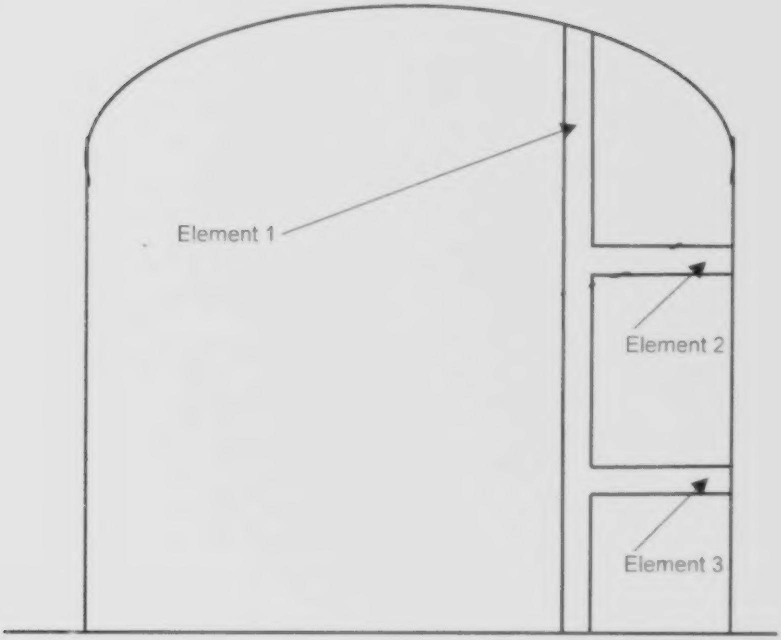
Equipment	3,020,500
Materials	21,438,068
Total	39,652,728

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating **Immersed Tube Rail Option**
North Drill & Blast Approach Finishes
Tunnel Structural Finishes

Page 1 of 2
Date: June 07, 2004
Calculation by: A.White

Tunnel length= 6550 m

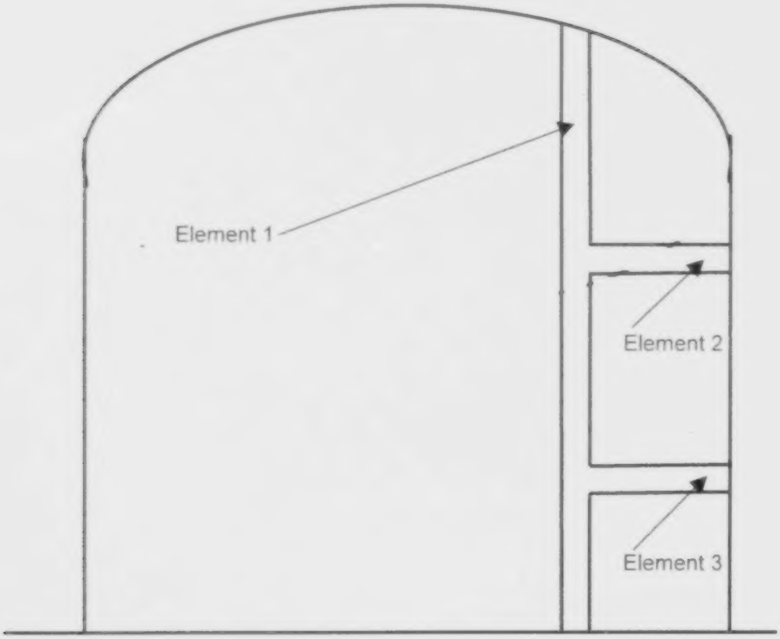

Element 1
Element 2
Element 3

Assumed tunnel cross section

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating **Immersed Tube Rail Option**
North Drill & Blast Approach Finishes
Tunnel Structural Finishes

Page 1 of 2
Date: June 07, 2004
Calculation by: A.White

Tunnel length= 6550 m


Element 1
Element 2
Element 3

Assumed tunnel cross section

APPENDIX D (9)

IMMERSED TUBE RAIL TUNNEL COSTS

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating **Immersed Tube Rail Option**
North Drill & Blast Approach Finishes
Tunnel Structural Finishes

Date: June 07, 2004
Calculation by: A.White

Quantity Take-off

Concrete

Element	Nr.	L(m)	b(m)	d(m)	Concrete Qty(m3)		Rebar Qty(m3)	
1	1	6550	0.3	6.9	13559		1627.0	
2	1	6550	1.5	0.3	2947.5		353.7	
3	1	6550	1.5	0.3	2947.5		353.7	
4	1	6550	5.5	1.0	36025		4323.0	
					55479	m3	6657	t

Formwork/falsework

Element	Nr.	L(m)	d(m)	Faces	Area(m2)	
1	1	6550	6.9	2	90390	
2	1	6550	1.5	1	9825	
3	1	6550	1.5	1	9825	
4	1	6550	0	0	0	
					110040	m2

Rates

Concrete	m3	190
Formwork	m2	140
Reinforcement	t	1600

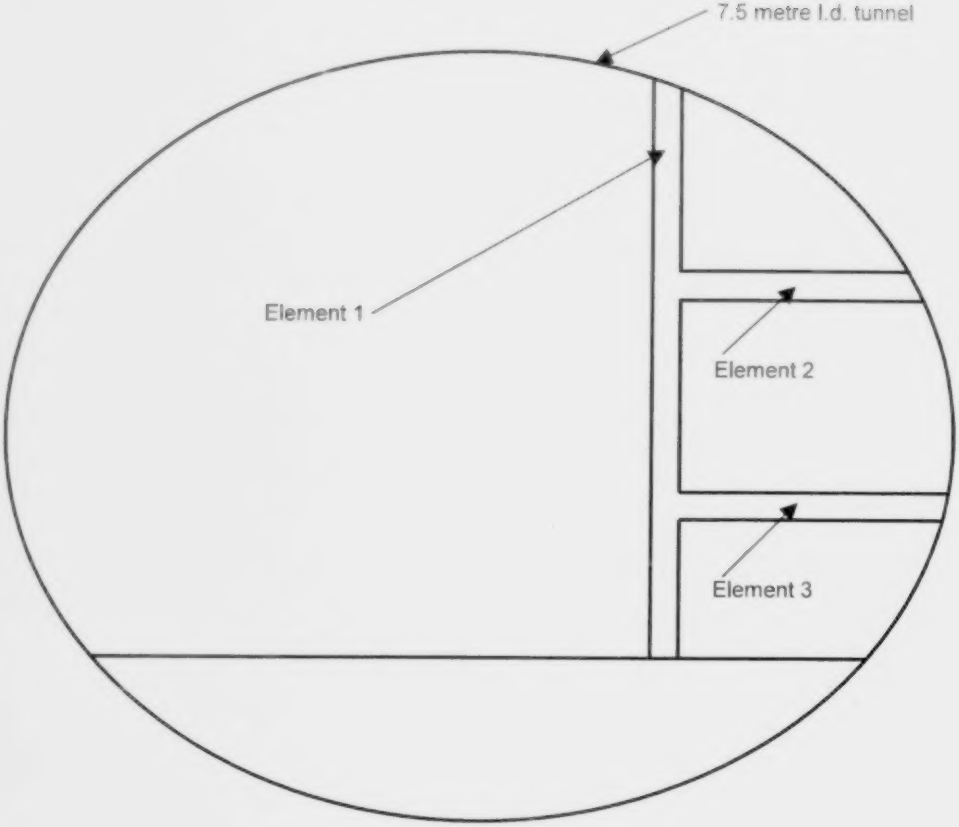
Costs

Concrete	m3	55479	m3	at	190	=	10,540,915
Formwork	m2	110040	m2	at	140	=	15,405,600
Reinforcement	t	6657	t	at	1600	=	10,651,872
						$	36,598,387

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating **Immersed Tube Rail Option**
Single Lane Bored Railway Tunnel
Tunnel Structural Finishes

Page 1 of 2
Date: June 07, 2004
Calculation by: A.White

Tunnel length= 6535 m


7.5 metre I.d. tunnel
Element 1
Element 2
Element 3

Assumed tunnel cross section

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating **Immersed Tube Rail Option**
North Drill & Blast Approach Finishes
Tunnel Structural Finishes

Page 2 of 2
Date: June 07, 2004
Calculation by: A.White

Quantity Take-off

Concrete

Element	Nr.	L(m)	b(m)	d(m)	Concrete Qty(m3)		Rebar Qty(m3)	
1	1	6550	0.3	6.9	13559		1627.0	
2	1	6550	1.5	0.3	2947.5		353.7	
3	1	6550	1.5	0.3	2947.5		353.7	
4	1	6550	5.5	1.0	36025		4323.0	
					55479	m3	6657	t

Formwork/falsework

Element	Nr.	L(m)	d(m)	Faces	Area(m2)	
1	1	6550	6.9	2	90390	
2	1	6550	1.5	1	9825	
3	1	6550	1.5	1	9825	
4	1	6550	0	0	0	
					110040	m2

Rates

Concrete	m3	190
Formwork	m2	140
Reinforcement	t	1600

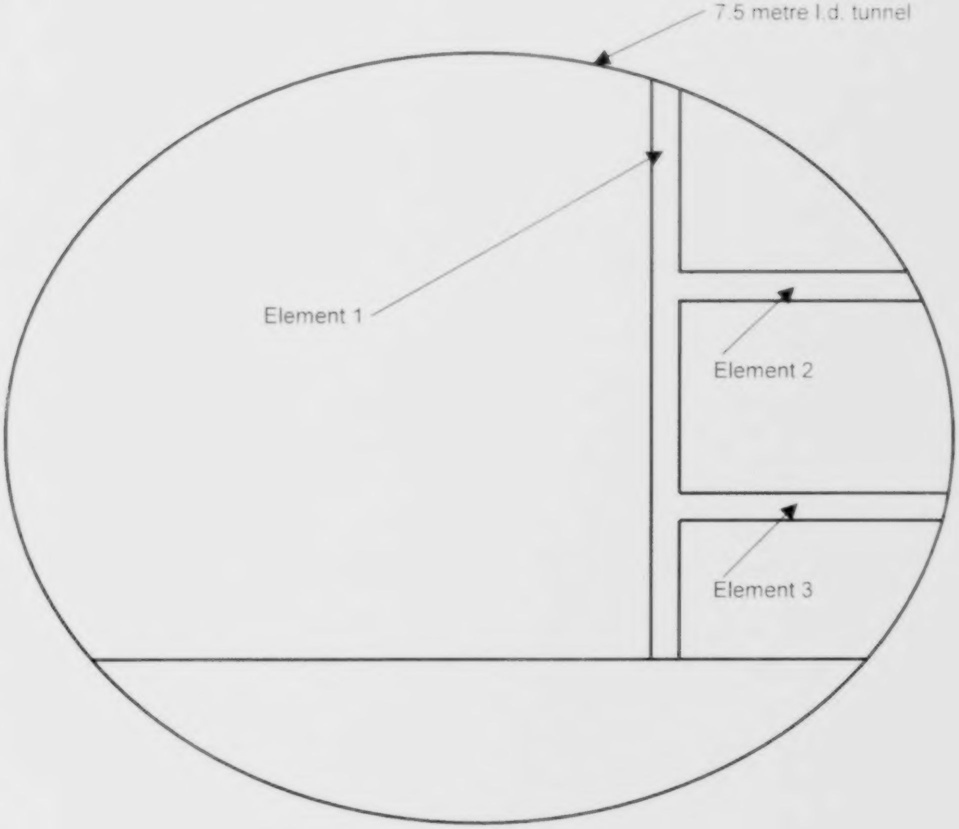
Costs

Concrete	m3	55479	m3	at	190	=	10,540,915
Formwork	m2	110040	m2	at	140	=	15,405,600
Reinforcement	t	6657	t	at	1600	=	10,651,872
						$	36,598,387

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating **Immersed Tube Rail Option**
Single Lane Bored Railway Tunnel
Tunnel Structural Finishes

Page 1 of 2
Date: June 07 2004
Calculation by: A White

Tunnel length= 6535 m


7.5 metre I.d. tunnel
Element 1
Element 2
Element 3

Assumed tunnel cross section

Hatch Mott MacDonald

Detailed Cost Estimate Report

[illegible]

Copyright Hatch Mott MacDonald 2002

Version VANC-1.5

Project:	**Newfoundland Fixed Link Study**	**Project Number:**	213789
Estimate Description:	Prefeasibility Level	**Parent Estimate ID:**	V-300
Tunnel Name:	IT Rail - South D&B Approach	**Project Phase:**	Prefeasibility Design
Construction Activity:	Excavation (Drill & Blast) & Initial Support	**Geology Type:**	Poor to Fair Sediments & Volcanics
Estimate Definition ID:	V-315	**Estimate Date:**	June 11 2004

Tunnel Characteristics

Tunnel Length:	**2,100.0**		m
Design Width:	**6.4**		m
Design Wall Height (Ave.)	**6.6**		m
Design Wall to Roof:	**2.5**		
Design Max Height :	9.1		m
Ave Tunnel Overbreak:	**20.0**		cm
Tunnel Face Area:	59.3	(Includes Overbreak)	m^2
Crown Perimeter:	9.6	(Includes Overbreak)	m
Wall & Crown Perimeter:	23.2	(Includes Overbreak)	m
Wall & Crown Area:	48,748	(Includes Overbreak)	m^2
Neat Tunnel Excav. Vol.:	124,530	(Includes Overbreak)	m^3
Re-Muck / Pull-Out Bays:			
Bay Length:	**10.0**		m
Spacing Bttn Bays:	**1000.0**		m
Number of Bays:	2		No
Total Length of Bays:	20.0		m
Neat Excavation Vol.:	1,186		m^3
Total Tunnel Volume:	125,716		m^3
Muck Bulking Factor:	**1.6**		Ratio
Bulked Tunnel Volume:	201,145	(Loose Muck Volume)	m^3

Primary Mucking Production Details

(Activity to remove blast muck from face to conveyor & muck cars)

Muck Volume / Blast:	313.1		m^3
Mucking Volume / Trip:	**5.00**		m^3
Bucket Fill Factor (%):	**90.0**		%
Number of Trips:	70		No
Ave. Dist. to Load:	**35.0**	(Ave Distance One Way)	m
Ave. Tramming Speed:	**8.0**		km/hr
Load, Dump, Manoever:	**1.0**	(Time per Trip)	Min
Face Cleanup / Blast:	**15.0**		Min
Mucking Time:	2.0		Hours
Mucking Rate:	155.1		m^3 / Hour

Tunnel Support Class Details

Class I - No Support:	**0.0**	(%)	0	(m)
Class II - Spot Bolts:	**0.0**	(%)	0	(m)
Class III - Crown Only:	**40.0**	(%)	840	(m)
Class IV - Full Pattern:	**50.0**	(%)	1,050	(m)
Class V - Steel Sets:	**10.0**	(%)	210	(m)
Total	100.0		2,100	(m)

Initial Shotcrete Support Details

Support Arc Length:	**23.2**	m
Thickness:	**25.0**	mm
Volume / Round:	2.2	m^3

Shift Details

Shift Arrangement:	**3.0**	Shifts / Day
	8.0	Hours / Shift
	5.0	Days / Week

Drill, Charge, Blast, Vent & Mucking Details

Survey Tunnel / Holes / Map:	**30.0**	Min / Cycle
Drilling Blast Holes:		
Hole Length:	**3.9**	m / Hole
Perim. Blast Hole Spacing:	**0.50**	m
Interior Blast Hole Spacing:	**1.25**	m
No. Perimeter Holes:	46	No
No. Interior Area Holes:	38.0	No
No. Blast Initiation Holes:	14	No
Number of Drillholes / Blast:	99	Blastholes / Blast
Blast Hole / Face Area Ratio:	1.67	Holes / m^2
Typical / Check Ratio:	1.56	Holes / m^2
Drill Eqpt Set-Up Time:	**20**	min / Set-up
Drill Penetration Rate:	**1.50**	m / Min
	90	m/hour
# of Drills or Booms:	**3.0**	No
Charging & Blasting:		
Prime & Load Rate / Hole:	**1.25**	min / Blasthole
Prep & Hook-up Time:	**20.0**	min / Set-up
Total No. Blasts / Tunnel:	642	No
Net Blast Break Length:	**3.3**	m / Blast
Blast & Ventilation Time:	**0.5**	Hours

Pre-Excavation Grouting Details

% Tunnel to be Grouted:	**5.0**	%
Tunnel Length to Grout:	105	m
Grout Hole Length:	**7.0**	m
No. of Grouting Applications:	15	No
Perim. Grout Holes Spacing:	**1.50**	m
# Perim. Grout Holes:	15	Holes / Grout Cycle
Drilling Penetration Rate:	**50**	m/hour
No. of Drill Booms:	**2**	No
Drilling Time per Cycle:	16	Min
Grout Eqpt. Set-Up Time:	**1.0**	Hours / Grout Cycle
No. of Holes Grouted at Once:	**2**	Hoses
Grouting Injection Rate:	**10**	min / Drillhole
Full Grout Cycle Time:	26.4	Hours

Steel Set Installation Details

Steel Set Spacing:	**1.0**	m
Total No. Sets / Tunnel:	210	No
Ave. Installation Time / Set:	**3.0**	Hours

Estimated by PJP
Checked by

Time:	0.8 (Includes Scaling & Equip Set-up)	Hours	**Total Installation Time:**	630	Hours

Estimated by PJP
Checked by

Wiremesh Installation Details

Install Rate:	**100**		m^2 / Hour
Total Install Time:	537.5		Hours
Ave. Install Time:	50.2		Min
Overlap:	**5**		%
Net Applied Area:	**48,748**	(Assume Class V only)	m^2
Area with Overlap:	53,745		m^2

Final Shotcrete Support Class Details

Shotcrete Thickness:		
Classes I and II:	**0**	mm
Class III:	**0**	mm
Classes IV:	**50**	mm
Class V:	**100**	mm
Support Arc Length:		
Class I:	**0.0**	m
Class II:	**0.0**	m
Class III:	**0.0**	m
Class IV:	**23.2**	m
Class V:	**23.2**	m

Initial and Final Shotcrete Application Details

Net Volume:	1,706		m^3
Rebound / Waste:	**15**		%
Final Layer Volume:	1,962		m^3
No. of Applications:	**369**	(Required Per Bench)	No.
Ave. Vol. / Application:	5.3		m^3
Surface Prep Time:	**10.0**		Min
Total Surface Prep Time:	3,691		Min
Application Rate:	**24.0**		m^3 / Hour
Total Application Time:	4,905		Min
Eqpt. Setup Time:	**20.0**		Min
Total Setup Time:	7,382		Min
Eqpt. Remove Time:	**10.0**	(Required Per Application)	Min
Total Remove Time:	3,691		Min
Total Shotcreting Time:	19,669	(For Final Shotcrete Layer)	Min
Equivalent Time / Blast:	30.6		Min / Cycle

Secondary Mucking Details

Req'd during Tunneling:	No	(No if loaded directly into trucks in tunnel)	
Ave. LHD Tram Speed:	**0.0**		km / hour

Wick Drain Installation Details

Drain Spacing:	**0.0**	m
Installation Time / Row:	**0.0**	Hours / Drain

Average Tunneling Productivity Cycle Details

Equiv. Pre-Exc. Grouting:	0.6		Hours
Drilling:	1.8		Hours
Charging:	2.4		Hours
Blast & Venting:	0.5		Hours
Mucking:	2.0		Hours
Scaling:	0.3		Hours
Surveying / Mapping:	0.5		Hours
Initial Shotcreting:	0.8		Hours
Install Services:	**0.5**	(Equiv. Time Per Cycle)	Hours
Non-Productive Time:	**0.5**	(Travel in/out, Break)	Hours
Include Rockbolting:	Yes	(Yes / No, as part of Cycle Time)	
If yes, % of Support Rq'd:	**30**	(% Req'd During Cycle for Poorer Ground)	
Rockbolting:	0.3		Hours
Total Cycle Time:	10.2		Hours

Rockbolt Support Class Details

	(Bolts Per Row)	(Bolts Per m)	(Bolts Per Support Class)
Class I:	**0**	0.0	0
Class II:	**0.0**	0.0	0
Class III:	**6**	4.0	3,360
Class IV:	**15**	10.0	10,500
Class V:	**0**	0.0	0
Total:			13,860

Face Scaling

Scaling Time:	**20.0**	min / Blast

Rockbolt Installation Details

Rockbolt Length:	**3.0**	m
Row Spacing:	**1.5**	m
No. Rockbolts Required:	13,860	No
Ave. Bolts / Round:	21.8	Bolts / Blast
Drilled Length / Round:	65	m
Total Drilling Length:	41,580	m
Drill Penetration Rate:	**1.5**	m / Min
# of Drills / Booms Used:	**3**	No
Ave. Drilling Time / Round:	14.5	Min
Bolt Install Rate	**2.0**	Min / Bolt
Ave. Bolt Install Time:	43.6	Min
Drill Set-Up Time:	**10.0**	Min
Total Bolt Drill/Install Time:	68.1	Min

Drainhole Details

Drainhole Spacing:	**3.0**	m
Drainhole Length:	**1.1**	m
Total Area:	24,374.2	m^2
Total Drainholes:	2,708.2	# / Per Tunnel
Total Length:	2,979.1	m

Note: Activity carried out concurrent with other activities

Duration of Tunneling:

Pre-Exc. Grouting Time =	395.4	Hours
Drilling Time =	1,130.7	Hours
Charge, Blast, Vent Time =	1,857.3	Hours
Primary Mucking Time =	1,296.7	Hours
Scaling Time =	642.8	Hours
Survey / Map Time =	321.2	Hours
Install Steel Sets Time =	630.0	Hours
Initial Shotcreting Time =	487.2	Hours
Install Services Time =	321.2	Hours
Rockbolting (of % Critical) =	218.7	Hours
Non-Productive Time =	321.2	Hours
Total Time =	7,622.4	Hours
	14.7	Months
(Critical Path Tunneling Activities Only)	63.5	Weeks
	317.6	Days

Other Concurrent Tunneling Activities

Rockbolting (of % Not Critical) =	510.3	Hours
Wiremesh Installation =	537.5	Hours
Final Shotcreting Time =	0.5	Hours
Drilling Drainholes =	794.4	Hours
Secondary Mucking =	0.0	Hours
Wick Drain Installation =	0.0	Hours

Overall Advance Rate:

6.6	m / Day
392.1	m^3 / Day

Estimated by PJP
Checked by

Resource Type	Resource Name	Unit Rate	Unit	Quantity	Resource Quantity	Total
Labor						
	Miner - Shift Boss	50.68	$/hr	7,622.4	1.00	386,303.52
	Miner - Operator - Journeyman	47.84	$/hr	7,622.4	7.00	2,552,591.23
	Miner - Foreman	50.68	$/hr	7,622.4	3.00	1,158,910.57
	Miner - Laborer - Journeyman	47.40	$/hr	7,622.4	3.00	1,083,906.10
	Miner - Laborer - Apprentice	45.00	$/hr	7,622.4	3.00	1,029,024.77
	Tunnel Electrician - Journeyman	47.84	$/hr	7,622.4	3.00	1,093,967.67
					20.00	7,304,703.86
Plant						
	Cable - Fans & Pumps - High Voltage	120.00	$/m	2,100.0	0.20	50,400.00
	Cable - Lights / Controls - Low Voltage	10.00	$/m	2,100.0	0.80	16,800.00
	Compressor	519.52	$/wk	63.5	1.00	33,000.00
	Conveyor - Heading Muck Loading	20,367.59	$/wk	63.5	1.00	1,293,750.00
	Drill - Jack-Leg	330.60	$/wk	63.5	4.00	84,000.00
	Drill Jumbo - Rail Mounted - 2 Boom	4,132.55	$/wk	63.5	1.00	262,500.00
	Drill Jumbo - Rail Mounted - 3 Boom	5,903.65	$/wk	63.5	1.00	375,000.00
	Excavator - Rail Mounted	1,298.80	$/wk	63.5	1.00	82,500.00
	Generator - Back-Up - 500KW	1,239.77	$/wk	63.5	1.00	78,750.00
	Generator - Working - 1000KW	9,256.92	$/wk	63.5	1.00	588,000.00
	Grout Plant-Consol-D&B-Pump, Hoses	779.28	$/wk	63.5	1.00	49,500.00
	Lighting (Including Consumables)	7.50	$/m	2,100.0	1.00	15,750.00
	Locomotive - Diesel - 16T	1,844.30	$/wk	63.5	4.00	468,600.00
	LHD Loader - D&B Tunnel	3,961.35	$/wk	63.5	1.00	251,625.00
	Manlift / Platform - Rail Mounted	1,731.74	$/wk	63.5	1.00	110,000.00
	Pipe - 50mm (Water Supply)	7.50	$/m	2,100.0	1.00	15,750.00
	Pipe - 100mm (Air Supply)	15.00	$/m	2,100.0	1.00	31,500.00
	Pipe - 150mm (DeWatering)	25.00	$/m	1,050.0	1.00	26,250.00
	Pipe - 250mm (Dewater)	70.00	$/m	1,050.0	1.00	73,500.00
	Pipe - Dewatering Clamps (<=200mm)	7.00	$/m	2,100.0	1.00	14,700.00
	Pumps - Dewatering - Tunnel - 50HP	397.43	$/wk	31.8	15.00	189,337.50
	Rail - 80 lb/yd - Used	101.54	$/m	4,600.0	0.60	280,246.15
	Rail - California Switch Gear	75,000.00	$/Nr	1.0	3.00	225,000.00
	Rail Car - Flat	50,000.00	$/Nr	1.0	3.00	150,000.00
	Rail Car - Man Rider	50,000.00	$/Nr	1.0	1.00	50,000.00
	Rail Car - Muck Cars	25,000.00	$/Nr	1.0	18.00	450,000.00
	Rail Car - Muck Car Tipping System	75,000.00	$/Nr	1.0	1.00	75,000.00
	Shotcrete Machine - Rail Mounted	1,900.97	$/wk	63.5	1.00	120,750.00
	Shotcrete Machine - Tire Mounted	3,077.77	$/wk	63.5	2.00	391,000.00
	Small Tools	200.00	$/wk	63.5	1.00	12,704.01
	Tie Plates, Splice Bars, Bolts	150,000.00	LS	1.0	1.00	150,000.00
	Ties - Wooden - Untreated - 7" x 9" x 40"	23.00	$/m	2,100.0	1.00	48,300.00
	Transformers & Switchgear - High Voltag	865.87	$/wk	63.5	1.00	55,000.00
	Transformers-Switchgear-Low Voltage	432.93	$/wk	63.5	1.00	27,500.00
	Ventilation Duct - Rigid	110.00	$/m	2,100.0	1.00	231,000.00
	Ventilation Fans - 75HP	244.41	$/wk	63.5	7.00	108,675.00
	Welder (Plant)	27.16	$/wk	63.5	1.00	1,725.00
						6,488,112.66

Estimated by PJP
Checked by

Resource Type	Resource Name	Unit Rate	Unit	Quantity	Resource Quantity	Total
Consumables						
	Bits, Powder and Caps - Blasting	15.00	$/m3	125,715.8	1.00	1,885,737.15
	Bits - (Drainholes & Rockbolts)	5.00	$/m	44,559.1	1.00	222,795.33
	Drill Jumbo Maintenance	100.00	$/hr	1,081.6	1.00	108,156.51
	Electricity - Tunnel Heading Conveyor	0.22	$/kwh	150	160.61	5,300.00
	Electricity - Fans & Lighting	0.22	$/kwh	398	3,811.20	333,534.90
	Electricity - Jumbo	0.22	$/kwh	75	1,081.57	17,845.82
	Electricity - Pumps Dewatering	0.22	$/kwh	559	5,335.68	656,505.14
	Lubricants	2,500.00	$/wk	63.5	1.00	158,800.12
	Fuels & Lubricants	5,000.00	$/wk	63.5	1.00	317,600.24
	Other Consumables	1,500.00	$/wk	63.5	1.00	95,280.07
						$ 3,801,555.29
Materials						
	Grout - Consolidation	50.00	$/m3	2,000.0	1.00	100,000.00
	Other Materials	2,000.00	$/wk	63.5	1.00	127,040.10
	Rock Bolts - No.10 - 3.0m - (Non-Galv)	40.00	$/Nr	13,860	1.00	554,400.00
	Shotcrete	180.00	$/m3	1,962.1	1.00	353,181.90
	Steel Sets - W10 x 65	152.75	$/m	210	23.21	744,631.26
	Synthetic Wick Drains	5.00	$/m	0	1.00	-
	WWF mesh	5.50	$/m2	53,745	1.00	295,597.89
						$ 1,779,253.26
Subcontracts						
	Tunnel Muck - Miscl Surface Handling	20.00	$/m3	201,145.30	1.00	4,022,905.91
						$ 4,022,905.91
					Total Estimated Cost:	**$ 23,396,530.99**
					Per Meter:	$ 11,141.21
					Per m^3:	$ 186.11

Estimated by PJP
Checked by

Newfoundland Fixed Link Pre-feasibility Study
IT Rail Tunnel - South D&B Approach Final Liner
Tunnel Final Liner Cost Estimate

Tunnel length= 2100 m
Liner cross section area= 13.5 m2

Shift pattern

Shifts	Hours	Days
3	8	5

Advance rate= 10 m/day

Rebar ratio= 0.12 t/m3 of concrete

Concrete supply=$ 135 /m3

Rebar supply=$ 900 /t

Initial form set-up time= 4 weeks

Durations

Number of days= 230 days
Number of hours= 5520 hours
Number of weeks= 46 weeks

Labour

Crew size 20
Average labour rate $ 47 /hour

Total labour cost=$ 5,188,800

Equipment

Form $ 1000000
Weekly cost of other equipment $ 15000 (see TED 2370)

Total equipment cost=$ 1,690,000

Materials

Concrete= 28350 m3
Rebar= 3402

Concrete cost=$ 3,827,250
Rebar cost=$ 3,061,800

Total material cost=$ 6,889,050

Cost Summary

Labour	5,188,800
Equipment	1,690,000
Materials	6,889,050
Total	**13,767,850**

Newfoundland Fixed Link Pre-feasibility Study
IT Rail Tunnel - South D&B Approach Final Liner
Tunnel Final Liner Cost Estimate

Tunnel length= 2100 m
Liner cross section area= 13.5 m2

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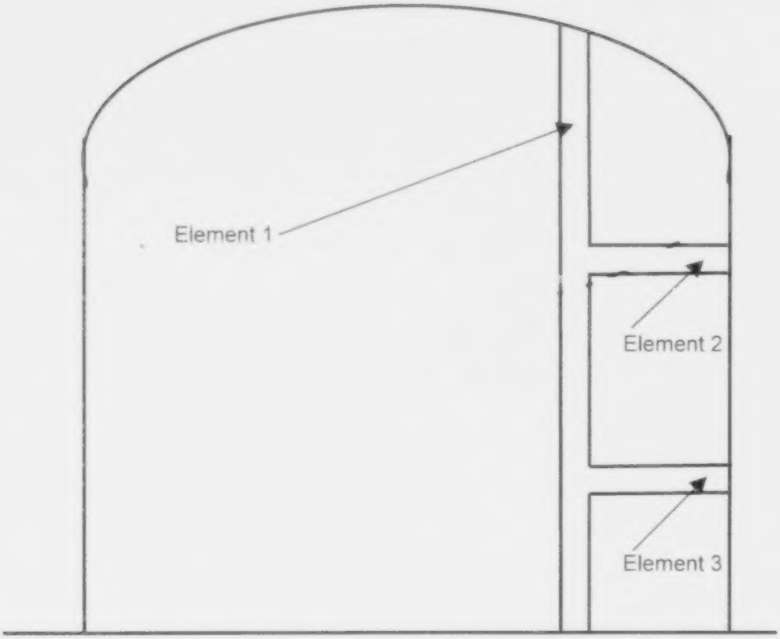
Labour	5,188,800
Equipment	1,690,000
Materials	6,889,050
Total	13,767,850

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
IT Rail Tunnel - South D&B Approach Finishes
Tunnel Structural Finishes

Page 1 of 2
Date: June 07, 2004
Calculation by: A.White

Tunnel length= 2100 m


Element 1
Element 2
Element 3

Assumed tunnel cross section

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
IT Rail Tunnel - South D&B Approach Finishes
Tunnel Structural Finishes

Page 2 of 2
Date: June 07, 2004
Calculation by: A.White

Quantity Take-off

Concrete

Element	**Nr.**	**L(m)**	**b(m)**	**d(m)**	**Concrete Qty(m3)**	**Rebar Qty(m3)**
1	1	2100	0.3	6.9	4347	521.6
2	1	2100	1.5	0.3	945	113.4
3	1	2100	1.5	0.3	945	113.4
4	1	2100	5.5	1.0	11550	1386.0
					17787 m3	2134 t

Formwork/falsework

Element	**Nr.**	**L(m)**	**d(m)**	**Faces**	**Area(m2)**
1	1	2100	6.9	2	28980
2	1	2100	1.5	1	3150
3	1	2100	1.5	1	3150
4	1	2100	0	0	0
					35280 m2

Rates

Concrete	m3	190
Formwork	m2	140
Reinforcement	t	1600

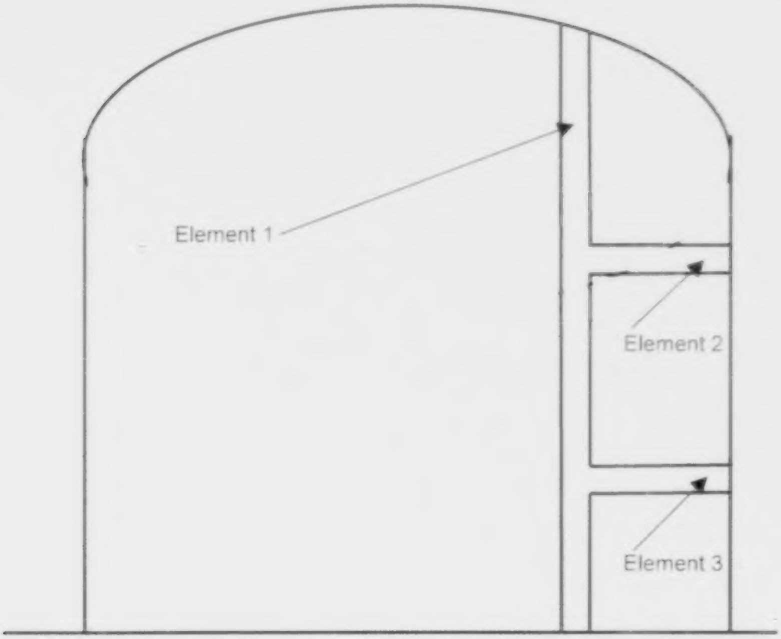
Costs

Concrete	m3	17787	m3	at	190	=	3,379,530
Formwork	m2	35280	m2	at	140	=	4,939,200
Reinforcement	t	2134	t	at	1600	=	3,415,104
						$	11,733,834

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
IT Rail Tunnel - South D&B Approach Finishes
Tunnel Structural Finishes

Page 1 of 2
Date: June 07 2004
Calculation by: A.White

Tunnel length= 2100 m



Element 1
Element 2
Element 3

Assumed tunnel cross section

Newfoundland Fixed Link Pre-feasibility Study
Cost Estimating
IT Rail Tunnel - South D&B Approach Finishes
Tunnel Structural Finishes

Date: June 07, 2004
Calculation by: A.White

Quantity Take-off

Concrete

Element	Nr.	L(m)	b(m)	d(m)	Concrete Qty(m3)	Rebar Qty(m3)
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4	1	2100	5.5	1.0	11550	1386.0
					17787 m3	2134 t

Formwork/falsework

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					35280 m2

Rates

Concrete	m3	190
Formwork	m2	140
Reinforcement	t	1600

Costs

Concrete	m3	17787	m3	at	190	=	3,379,530
Formwork	m2	35280	m2	at	140	=	4,939,200
Reinforcement	t	2134	t	at	1600	=	3,415,104
						$	11,733,834

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: South Approach
Option: Immersed Tube Rail Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient	0	%	+ sloping same way as track/road - sloping against track/road
Track/Road Gradient	1.83	%	
Ground elevation at portal	100	m	
Bottom of slab elevation at portal	86.95	m	
Total length=	713.1148	m	
Total Cost=$	6.1	M	

Newfoundland Fixed Link Pre-feasibility Study Date: 8-Jun-04
South Approach Calculations by: ANW
Immersed Tube Rail Tunnel

UNIT RATES

Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Initialisation

Project: Newfoundland Fixed Link Pre-feasibility Study
Section: South Approach
Option: Immersed Tube Rail Tunnel

Date: 8-Jun-04

Calculations by: ANW

Surface gradient 0 %

+ sloping same way as track/road
- sloping against track/road

Track/Road Gradient 1.83 %

Ground elevation at portal 100 m

Bottom of slab elevation at portal 86.95 m

Total length= 713.1148 m

Total Cost=$ 6.1 M

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Immersed Tube Rail Tunnel

UNIT RATES

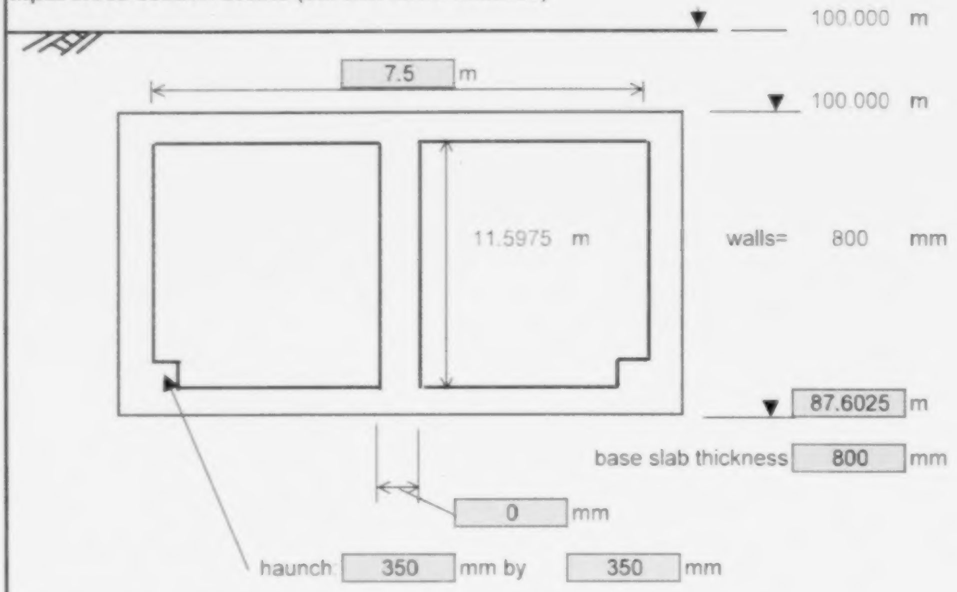
Materials

Item	unit	Rate
excavation	m3	60
concrete	m3	190
rebar	tonnes	1600
formwork/falsework	m2	140
SP&L<=4.6m deep	m2	0
4.6<SP&L<=6.7m deep	m2	0
6.7<SP&L<=10.6m deep	m2	0
10.6<SP&L<=13.7m deep	m2	0
13.7<SP&L<=16.8m deep	m2	0
16.8<SP&L<=20.0m deep	m2	0
20<SP&L<=25m deep	m2	0
backfill + compact	m3	40
surface reinstatement	m2	30

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Immersed Tube Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 71.31148 m **Section** 1

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
11.5975 m
walls= 800 mm
87.6025 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

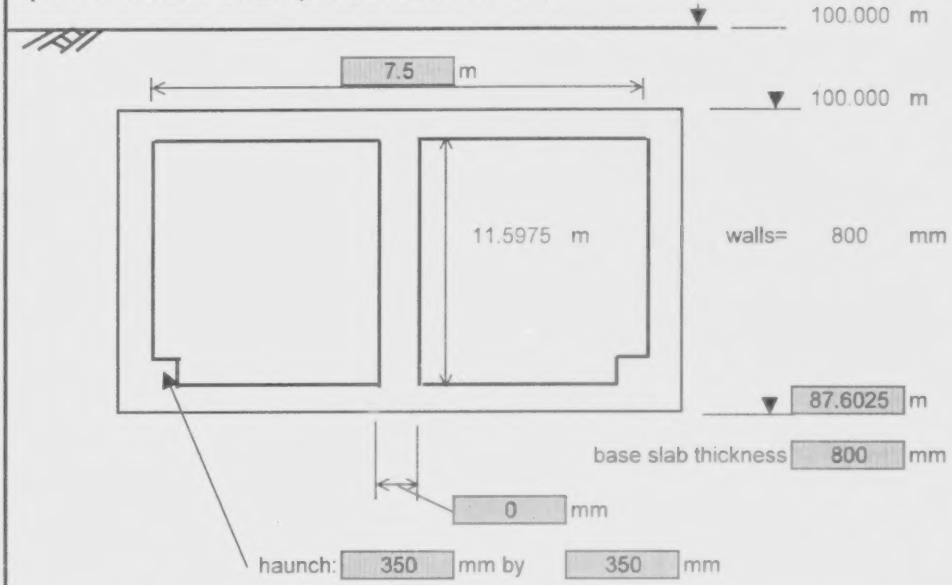
Calculated Quantities

excavation=	8045.2	m3	
concrete=	1859.875	m3	
rebar=	223.2	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1654.07	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1768.2	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	648.9344	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Immersed Tube Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 71.31148 m **Section 1**

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
11.5975 m
walls= 800 mm
87.6025 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	8045.2	m3	
concrete=	1859.875	m3	
rebar=	223.2	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1654.07	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1768.2	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	648.9344	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Immersed Tube Rail Tunnel **Page 2 of 2**

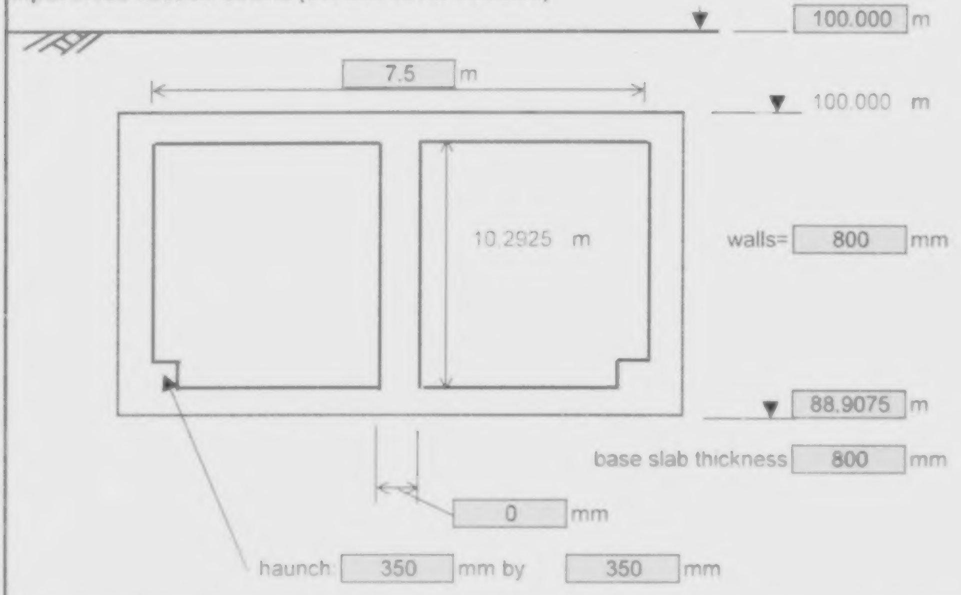
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	8045.2	60	482709.9
concrete	m3	1859.875	190.0	353376.2
rebar	tonnes	223.2	1600	357095.9
formwork/falsework	m2	1654.07	140	231569.8
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	1768.2	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	648.9344	30	19468.03
			Total	1444220

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Immersed Tube Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 71.31148 m **Section** **2**

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
10.2925 m
walls= 800 mm
88.9075 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	7198.3	m3
concrete=	1710.976	m3
rebar=	205.3	tonnes (assume 0.12t/m3 of concrete)
formwork/falsework=	1467.947	m2
SP&L<=4.6m deep	0.0	m2
4.6<SP&L<=6.7m deep	0.0	m2
6.7<SP&L<=10.6m deep	0.0	m2
10.6<SP&L<=13.7m deep	1582.0	m2
13.7<SP&L<=16.8m deep	0.0	m2
16.8<SP&L<=20.0m deep	0.0	m2
20<SP&L<=25m deep	0.0	m2
backfill=	0	m3
surface reinstatement=	648.9344	m2

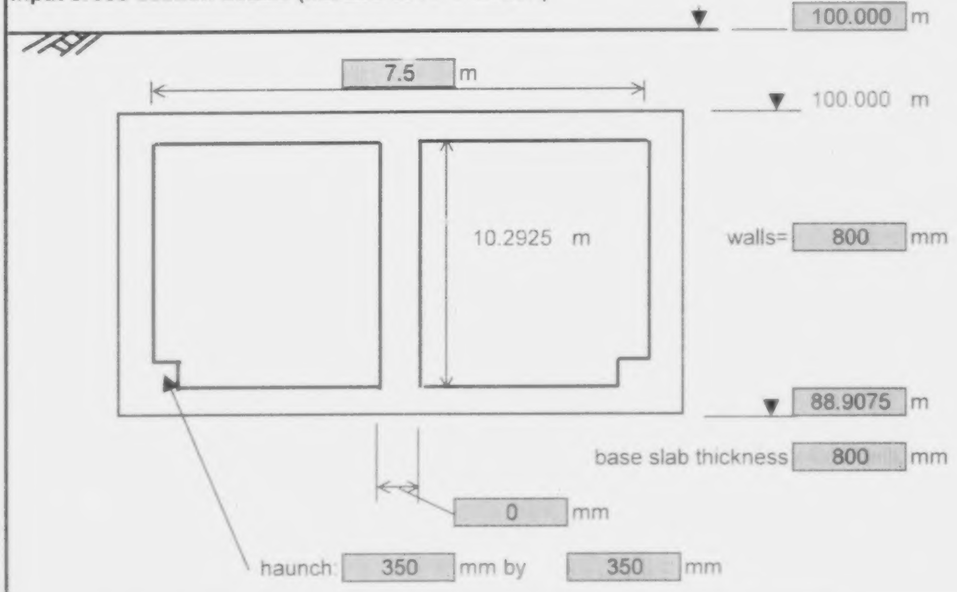
Newfoundland Fixed Link Pre-feasibility Study
South Approach
Immersed Tube Rail Tunnel

Date: 8-Jun-04
Calculations by: ANW
Page 1 of 2

Section Cut and Cover
Length of section: 71.31148 m

Section 2

Input cross-section details (cut and cover solution)



walls= 800 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	7198.3	m3	
concrete=	1710.976	m3	
rebar=	205.3	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1467.947	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	1582.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	648.9344	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Immersed Tube Rail Tunnel **Page 2 of 2**

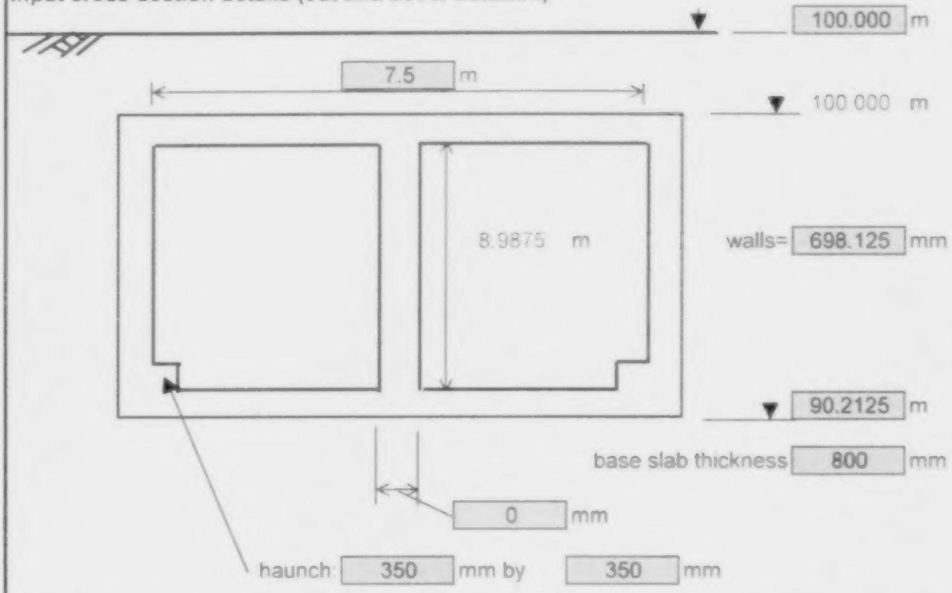
Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	7198.3	60	431898.3
concrete	m3	1710.976	190.0	325085.5
rebar	tonnes	205.3	1600	328507.4
formwork/falsework	m2	1467.947	140	205512.5
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	1582.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	648.9344	30	19468.03
			Total	1310472

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Immersed Tube Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 71.31148 m **Section** 3

Input cross-section details (cut and cover solution)



walls= 698.125 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	6209.2	m3
concrete=	1419.868	m3
rebar=	170.4	tonnes (assume 0.12t/m3 of concrete)
formwork/falsework=	1281.824	m2
SP&L<=4.6m deep	0.0	m2
4.6<SP&L<=6.7m deep	0.0	m2
6.7<SP&L<=10.6m deep	1395.9	m2
10.6<SP&L<=13.7m deep	0.0	m2
13.7<SP&L<=16.8m deep	0.0	m2
16.8<SP&L<=20.0m deep	0.0	m2
20<SP&L<=25m deep	0.0	m2
backfill=	0	m3
surface reinstatement=	634.4047	m2

Newfoundland Fixed Link Pre-feasibility Study
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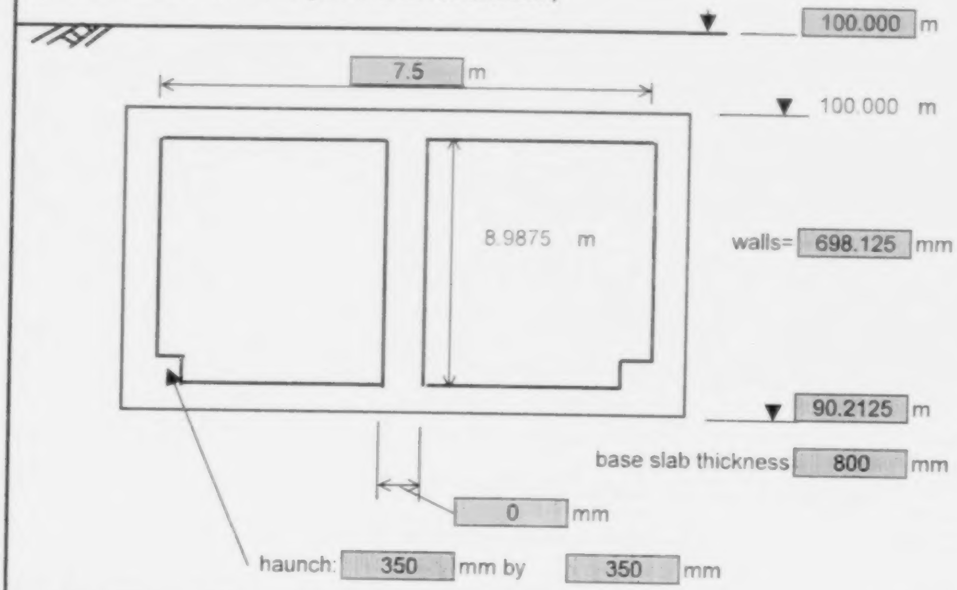
Section Cut and Cover
Length of section: 71.31148 m

Section 3

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
8.9875 m
walls= 698.125 mm
90.2125 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	6209.2	m3	
concrete=	1419.868	m3	
rebar=	170.4	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1281.824	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1395.9	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	634.4047	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	6209.2	60	372554.2
concrete	m3	1419.868	190.0	269775
rebar	tonnes	170.4	1600	272614.7
formwork/falsework	m2	1281.824	140	179455.3
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1395.9	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	634.4047	30	19032.14
			Total	1113431

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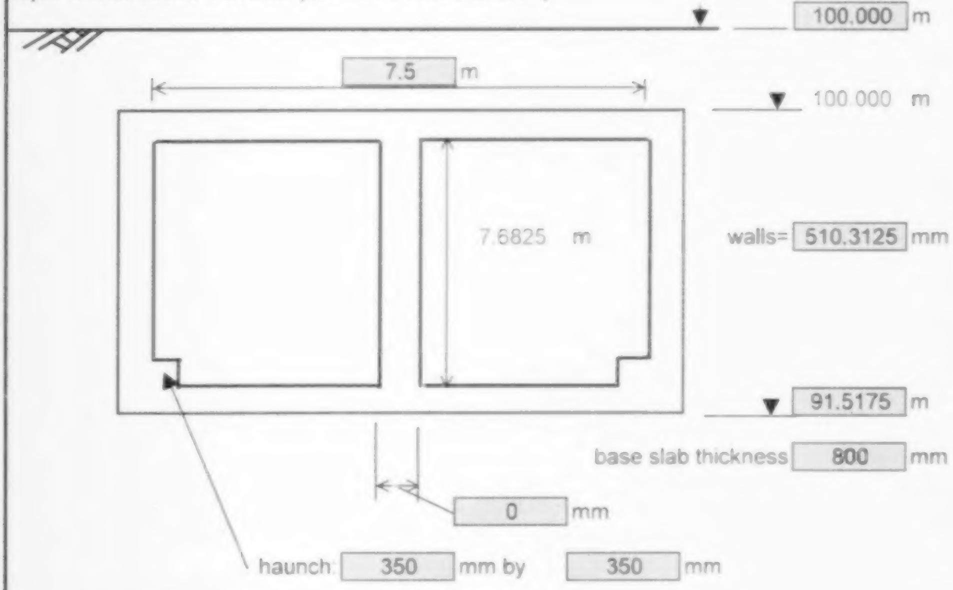
Section Cut and Cover

Length of section: 71.31148 m **Section** 4

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
7.6825 m
walls= 510.3125 mm
91.5175 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

Calculated Quantities

excavation=	5154.1	m3	
concrete=	1062.716	m3	
rebar=	127.5	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1095.701	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1209.8	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	607.6183	m2	

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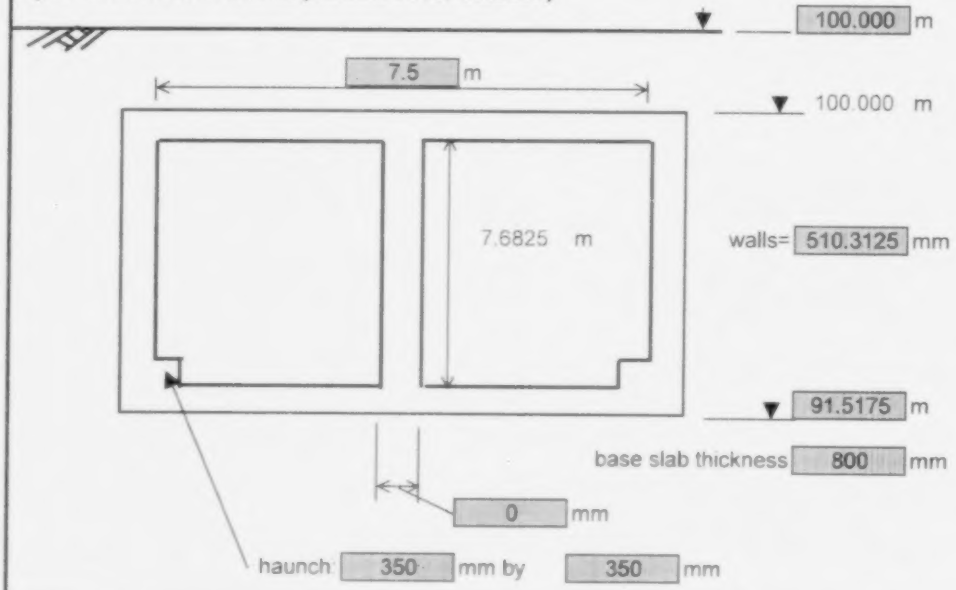
Section Cut and Cover
Length of section: 71.31148 m **Section 4**

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
7.6825 m
walls= 510.3125 mm
91.5175 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	5154.1	m3	
concrete=	1062.716	m3	
rebar=	127.5	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	1095.701	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1209.8	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	607.6183	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	5154.1	60	309247.4
concrete	m3	1062.716	190.0	201916
rebar	tonnes	127.5	1600	204041.4
formwork/falsework	m2	1095.701	140	153398.1
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1209.8	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&[illegible]16.8m deep	m2	0.0	0	0
16.8<SP[illegible]0m deep	m2	0.0	0	0
20<SP[illegible]=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	607.6183	30	18228.55
			Total	886831.5

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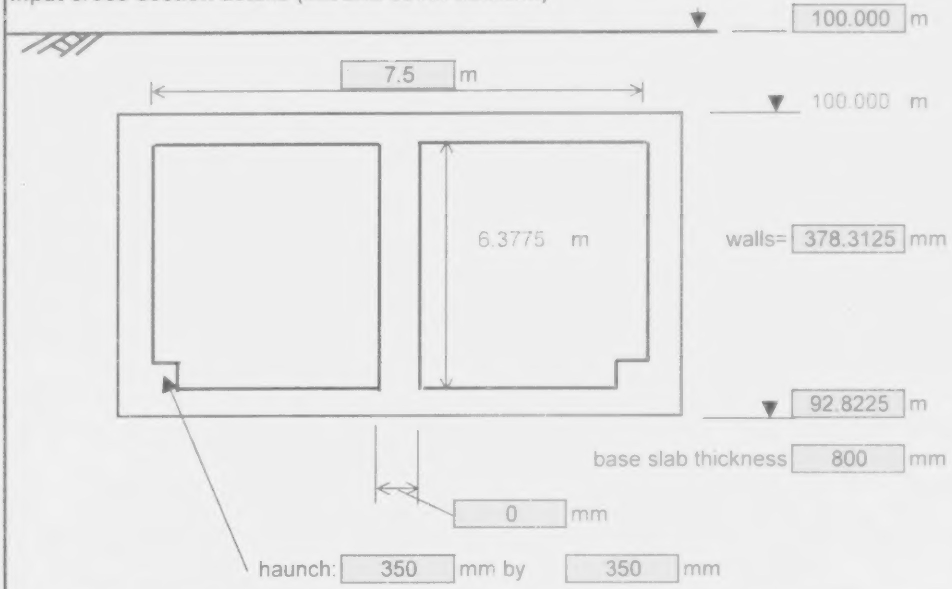
Section Cut and Cover
Length of section: 71.31148 m | **Section 5**

Input cross-section details (cut and cover solution)



walls= 378.3125 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	4226.1	m3	
concrete=	832.6097	m3	
rebar=	99.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	909.5779	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1023.7	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	588.7921	m2	

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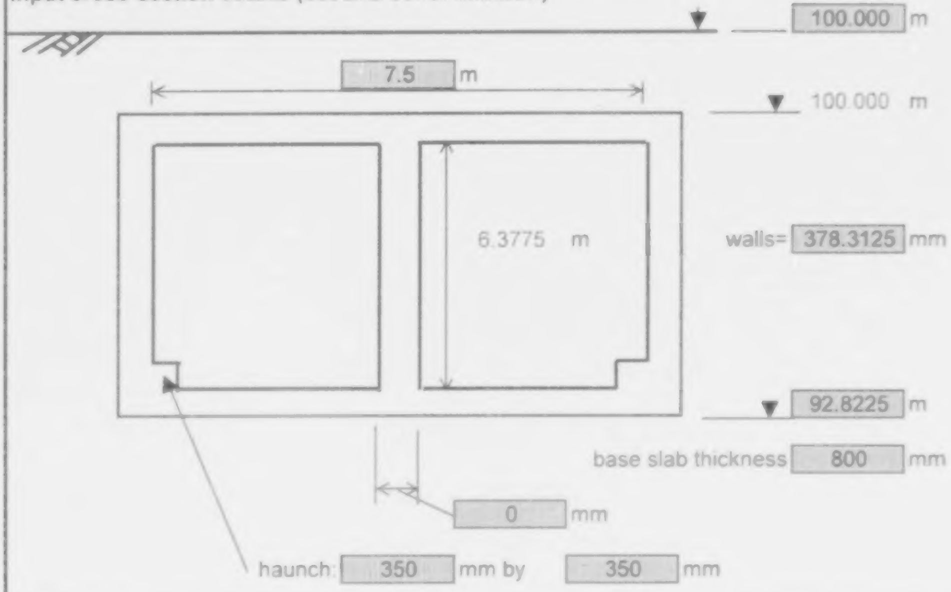
Section Cut and Cover
Length of section: 71.31148 m
Section 5

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
6.3775 m
walls= 378.3125 mm
92.8225 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	4226.1	m3	
concrete=	832.6097	m3	
rebar=	99.9	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	909.5779	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	1023.7	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	588.7921	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	4226.1	60	253563.3
concrete	m3	832.6097	190.0	158195.8
rebar	tonnes	99.9	1600	159861.1
formwork/falsework	m2	909.5779	140	127340.9
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	1023.7	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	588.7921	30	17663.76
			Total	716624.9

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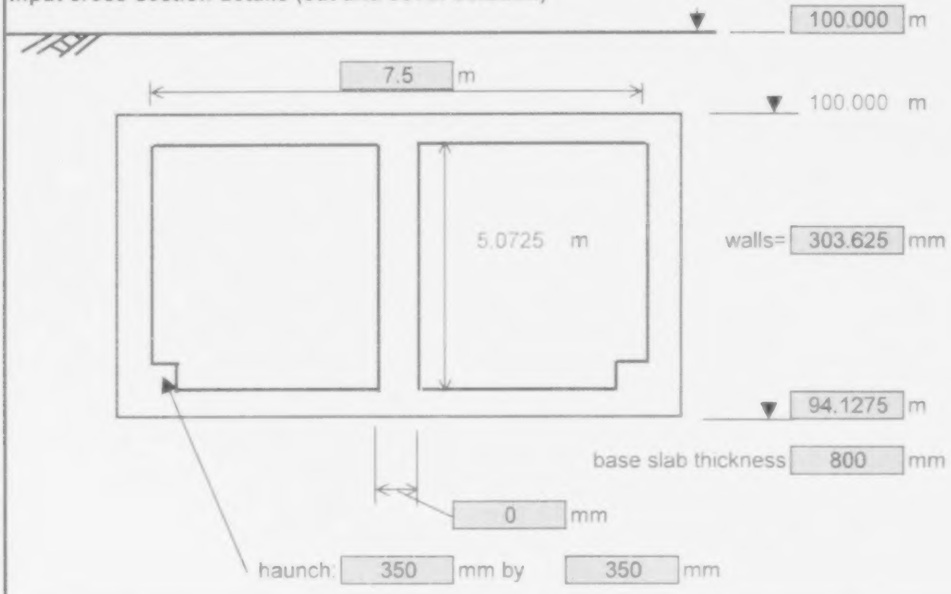
Section Cut and Cover
Length of section: 71.31148 m
Section 6

Input cross-section details (cut and cover solution)



walls= 303.625 mm

base slab thickness 800 mm

haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	3395.1	m3	
concrete=	699.6423	m3	
rebar=	84.0	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	723.4549	m2	
SP&L<=4.6m deep	0.0	m2	
4.6<SP&L<=6.7m deep	837.6	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	578.14	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	3395.1	60	203707.6
concrete	m3	699.6423	190.0	132932
rebar	tonnes	84.0	1600	134331.3
formwork/falsework	m2	723.4549	140	101283.7
SP&L<=4.6m deep	m2	0.0	0	0
4.6<SP&L<=6.7m deep	m2	837.6	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	578.14	30	17344.2
			Total	589598.9

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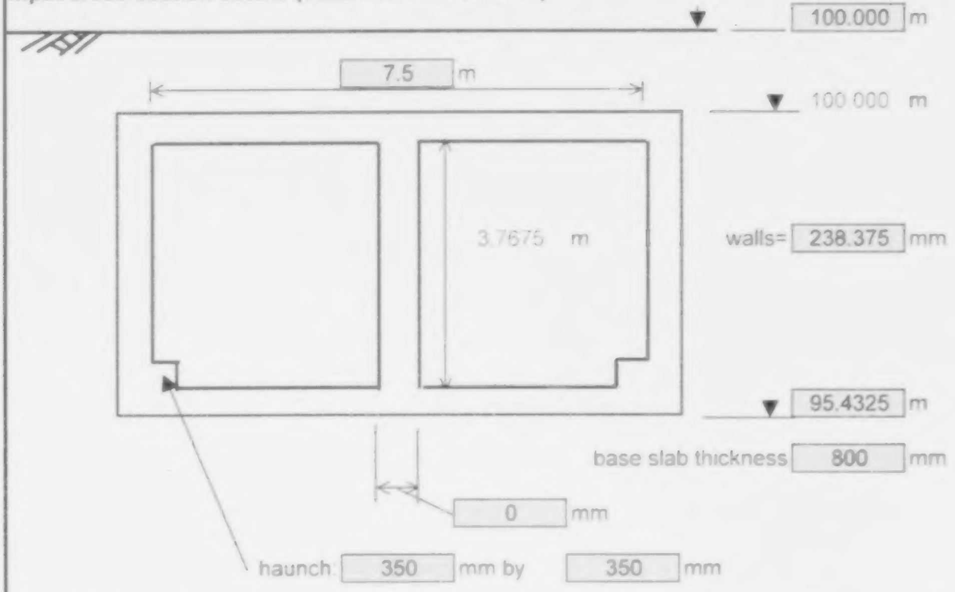
Section Cut and Cover
Length of section: 71.31148 m
Section 7

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
3.7675 m
walls= 238.375 mm
95.4325 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	2598.1	m3	
concrete=	600.6249	m3	
rebar=	72.1	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	537.332	m2	
SP&L<=4.6m deep	651.4	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	568.8338	m2	

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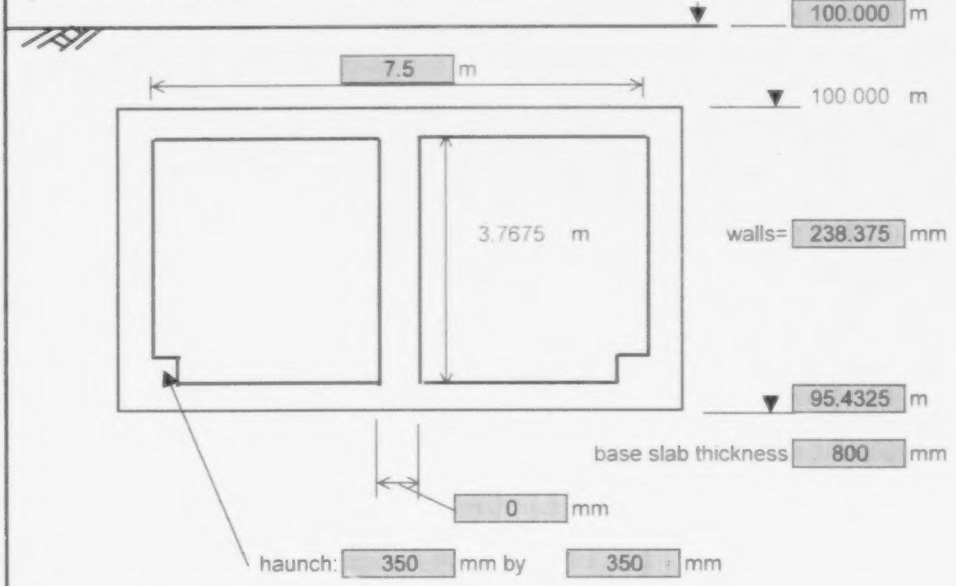
Section Cut and Cover
Length of section: 71.31148 m
Section 7

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
3.7675 m
walls= 238.375 mm
95.4325 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation= 2598.1 m3
concrete= 600.6249 m3
rebar= 72.1 tonnes (assume 0.12t/m3 of concrete)
formwork/falsework= 537.332 m2
SP&L<=4.6m deep 651.4 m2
4.6<SP&L<=6.7m deep 0.0 m2
6.7<SP&L<=10.6m deep 0.0 m2
10.6<SP&L<=13.7m deep 0.0 m2
13.7<SP&L<=16.8m deep 0.0 m2
16.8<SP&L<=20.0m deep 0.0 m2
20<SP&L<=25m deep 0.0 m2
backfill= 0 m3
surface reinstatement= 568.8338 m2

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	2598.1	60	155888.9
concrete	m3	600.6249	190.0	114118.7
rebar	tonnes	72.1	1600	115320
formwork/falsework	m2	537.332	140	75226.48
SP&L<=4.6m deep	m2	651.4	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	568.8338	30	17065.01
			Total	477619.1

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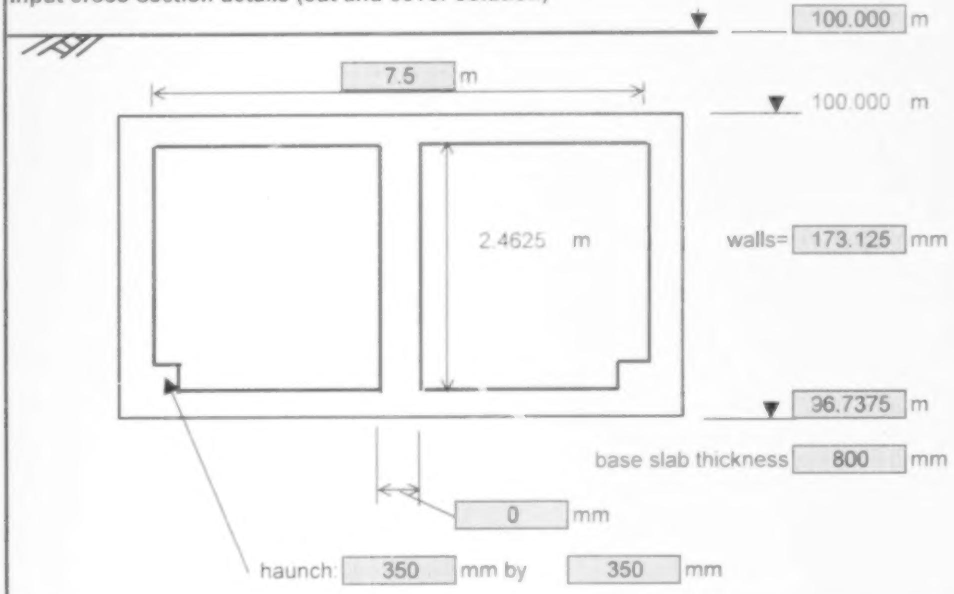
Section Cut and Cover
Length of section: 71.31148 m **Section** **8**

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
2.4625 m
walls= 173.125 mm
96.7375 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	1825.5	m3	
concrete=	525.8965	m3	
rebar=	63.1	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	351.209	m2	
SP&L<=4.6m deep	465.3	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	559.5277	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	1825.5	60	109527.5
concrete	m3	525.8965	190.0	99920.34
rebar	tonnes	63.1	1600	100972.1
formwork/falsework	m2	351.209	140	49169.26
SP&L<=4.6m deep	m2	465.3	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	559.5277	30	16785.83
			Total	376375.1

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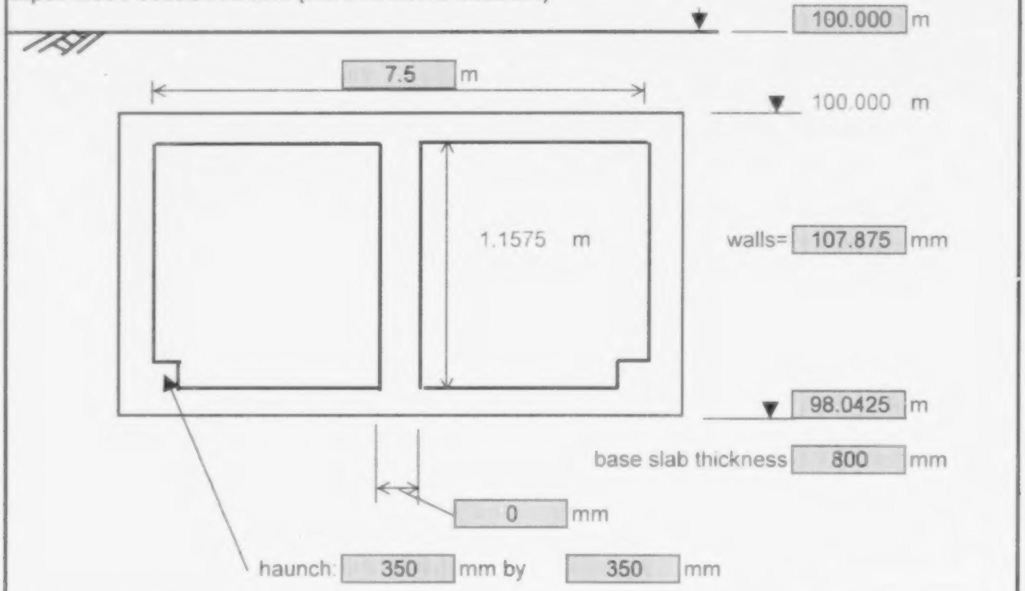
Section Cut and Cover
Length of section: 71.31148 m
Section 9

Input cross-section details (cut and cover solution)


100.000 m
7.5 m
100.000 m
1.1575 m
walls= 107.875 mm
98.0425 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	1077.1	m3	
concrete=	475.4572	m3	
rebar=	57.1	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	165.0861	m2	
SP&L<=4.6m deep	279.2	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	550.2215	m2	

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Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	1077.1	60	64623.52
concrete	m3	475.4572	190.0	90336.86
rebar	tonnes	57.1	1600	91287.78
formwork/falsework	m2	165.0861	140	23112.05
SP&L<=4.6m deep	m2	279.2	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	550.2215	30	16506.65
			Total	285866.9

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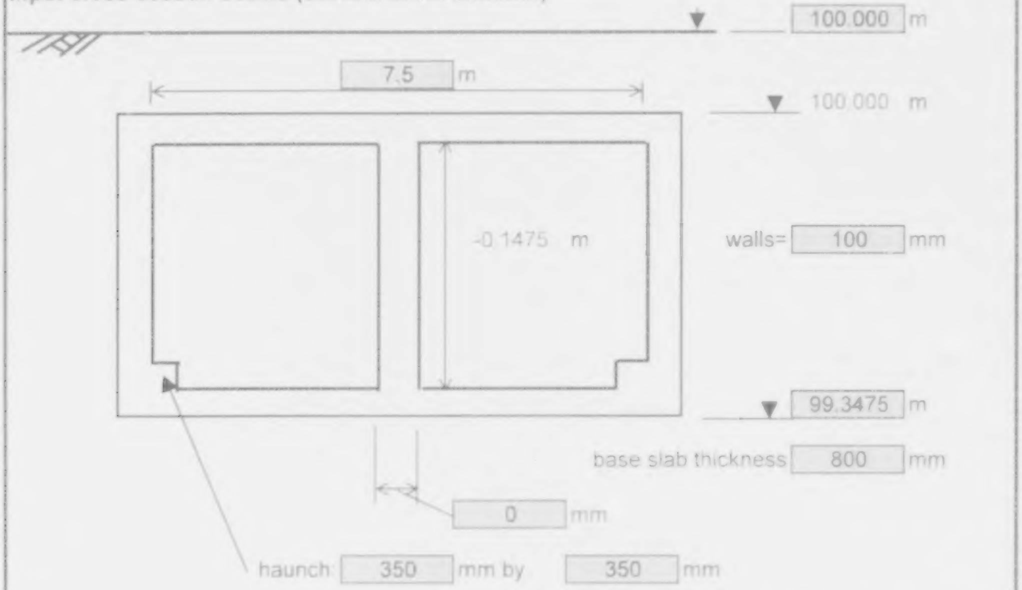
Section Cut and Cover
Length of section: 71.31148 m **Section** 10

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
-0.1475 m
walls= 100 mm
99.3475 m
base slab thickness 800 mm
0 mm
haunch 350 mm by 350 mm

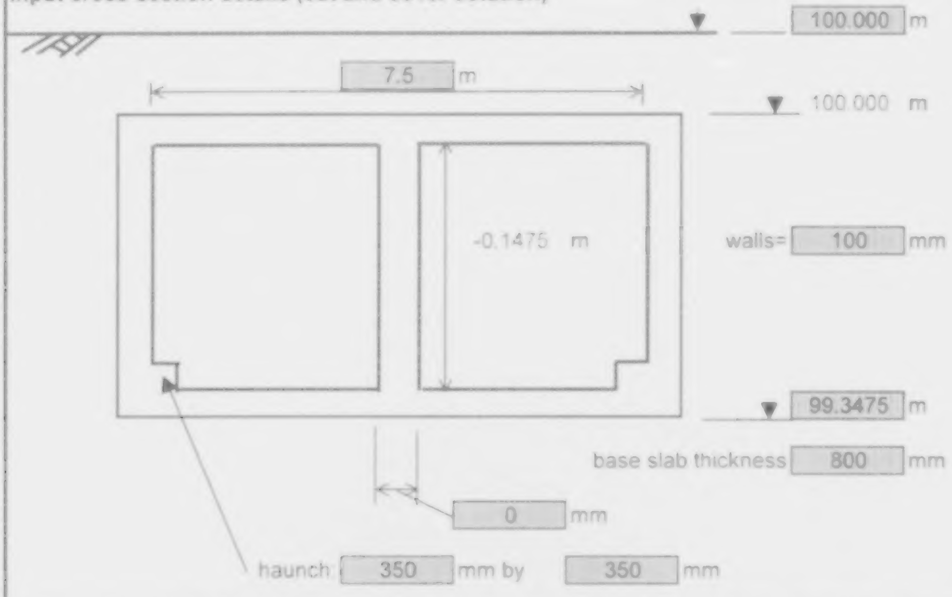
Calculated Quantities

excavation=	358.3	m3	
concrete=	454.6463	m3	
rebar=	54.6	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	-21.03689	m2	
SP&L<=4.6m deep	93.1	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	549.0984	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Immersed Tube Rail Tunnel **Page 1 of 2**

Section Cut and Cover
Length of section: 71.31148 m **Section** 10

Input cross-section details (cut and cover solution)



100.000 m
7.5 m
100.000 m
-0.1475 m
walls= 100 mm
99.3475 m
base slab thickness 800 mm
0 mm
haunch: 350 mm by 350 mm

Calculated Quantities

excavation=	358.3	m3	
concrete=	454.6463	m3	
rebar=	54.6	tonnes	(assume 0.12t/m3 of concrete)
formwork/falsework=	-21.03689	m2	
SP&L<=4.6m deep	93.1	m2	
4.6<SP&L<=6.7m deep	0.0	m2	
6.7<SP&L<=10.6m deep	0.0	m2	
10.6<SP&L<=13.7m deep	0.0	m2	
13.7<SP&L<=16.8m deep	0.0	m2	
16.8<SP&L<=20.0m deep	0.0	m2	
20<SP&L<=25m deep	0.0	m2	
backfill=	0	m3	
surface reinstatement=	549.0984	m2	

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Immersed Tube Rail Tunnel

Calculated costs

Item	Unit	Quantity	Rate	Cost
excavation	m3	358.3	60	21497.2
concrete	m3	454.6463	190.0	86382.8
rebar	tonnes	54.6	1600	87292.09
formwork/falsework	m2	-21.03689	140	-2945.164
SP&L<=4.6m deep	m2	93.1	0	0
4.6<SP&L<=6.7m deep	m2	0.0	0	0
6.7<SP&L<=10.6m deep	m2	0.0	0	0
10.6<SP&L<=13.7m deep	m2	0.0	0	0
13.7<SP&L<=16.8m deep	m2	0.0	0	0
16.8<SP&L<=20.0m deep	m2	0.0	0	0
20<SP&L<=25m deep	m2	0.0	0	0
backfill	m3	0	40	0
surface reinstatement	m2	549.0984	30	16472.95
			Total	208699.9

Newfoundland Fixed Link Pre-feasibility Study **Date:** 8-Jun-04
South Approach **Calculations by:** ANW
Immersed Tube Rail Tunnel

Summary of Costs

Markup for adjacent 0 %

Section	Cost
1	1444220
2	1310472
3	1113431
4	886831.5
5	716624.9
6	589598.9
7	477619.1
8	376375.1
9	285866.9
10	208699.9
Sub-total	6061178

APPENDIX D (10)

HIGHWAY CONNECTION COSTS

Newfoundland Fixed Link Pre-feasibility Study
Road Connections
Cost Estimate Summary

The following is a summary of the costs of road works associated with the project.

1		**Road Tunnel Concept**	Unit	Quantity	Unit Cost	Total Cost
1A		**Newfoundland Side**				
	0.1	New Road Construction	km	1.4	$550,000	$770,000
	0.2	Intersection Construction	allowance	1	$50,000	$50,000
	0.3	Marshalling Area	sq meter	36,000	$45	$1,620,000
		Sub Total Nfld Side				$2,440,000
1B		**Labrador Side**				
	0.1	New Road Construction	km	1	$600,000	$600,000
	0.2	Intersection Construction	allowance	1	$50,000	$50,000
	0.3	Marshalling Area	sq meter	36,000	$57	$2,052,000
		Sub Total Labrador Side				$2,702,000
2		**Rail Tunnel Concept**	Unit	Quantity	Unit Cost	Total Cost
2A		**Newfoundland Side**				
	0.1	New Road Construction	km	1.5	$550,000	$825,000
	0.2	Intersection Construction	allowance	1	$50,000	$50,000
	0.3	Marshalling Area	sq meter	36,000	$45	$1,620,000
		Sub Total Nfld Side				$2,495,000
2B		**Labrador Side**				
	0.1	New Road Construction	km	1	$600,000	$600,000

0.2	Intersection Construction	allowance	1	$50,000	$50,000
0.3	Marshalling Area	sq meter	36,000	$57	$2,052,000
	Sub Total Labrador Side				$2,702,000

3		**Quebec North Shore**				
	0.1	New Road Construction	km	350	$720,000	$252,000,000
	0.2	Road Upgrading	km	40	$360,000	$14,400,000
	0.3	Branch Roads	km	20	$312,000	$6,240,000
	0.4	Bridges	ea	9	$1,200,000	$10,800,000
		Sub Total Quebec North Shore Roads				$283,440,000
Total Road Costs						
		Road Tunnel				$288,582,000
		Rail Tunnel				$288,637,000

APPENDIX E

BREAKDOWN OF ROAD TUNNEL
OPERATING AND MAINTENANCE COSTS

Hatch Mott
MacDonald

Newfoundland Fixed Link Pre-feasibility Study

Highway Tunnel

Estimate of annual operating costs

A. Management and operation of tunnel control building

1. Manager (Assume 1 individual in full time management position)

Manager	2080	hrs/yr @	95	$/hr=	$	197600	/yr

2. Office assistants (assume 2 full time office assistants)

Office staff	4160	hrs/yr @	55	$/hr=	$	228800	/yr

3. Cleaners (assume 2 full time cleaners 5 days per week)

Cleaners	4160	hrs/yr @	45	$/hr=	$	187200	/yr
				Sub-total A - $		613600	/yr

B. Traffic Supervision Costs

1 Closed circuit TV system cost= $ 1062300
written-off over 40 years = $ 26557.5 /yr

2. Monitoring staff (assume full time monitoring by 2 men 24 hours per day

CCTV personnel	17472	hrs/yr @	60	$/hr=	$	1048320	/yr
				Sub-total B - $		1074878	/yr

C. Emergency Truck Costs

1. Assume 1 truck and each replaced every 15 years

Emergency truck costs= $ 70000
written-off over 15 years = $ 4666.667 /yr

2. Truck operators (assume 2 men for each truck 24 hours per day)

Truck operators	34944	hrs/yr @	60	$/hr=	$	2096640	/yr

3. Truck maintenance and fuel

Allow $ 20000 /yr

Sub-total C - $ 2121307 /yr

Estimate of annual operating costs

D. Energy Costs

2.7 kilometre long twin bore Eisenhower Highway Tunnel on I70 in Colorado has annual electricity bill of $840,000

Assume energy costs largely governed by tunnel length

For 20 km long tunnel Lane factor= 0.25

Energy cost - $ 777777.8

Sub-total D - $ 777778 /yr

Total Operating Cost - $ 4587562 /yr

Hatch Mott
MacDonald

Newfoundland Fixed Link Pre-feasibility Study
Highway Tunnel

Estimate of annual maintenance costs

A. Electrical Maintenance Costs

1. Labour (Assume equivalent of 1 electrician present at all times)

Electrician 1 8736 hrs/yr @ 65 $/hr= $ 567840 /yr

2. Materials/replacement of equipment (assume electrical equipment replaced once every 40 years)

Electrical equipment cost= $ 7035000 (sub-station, generators, etc.)
written-off over 40 years = $ 175875 /yr

Fire suppression equipment cost= $ 4000000
written-off over 40 years = $ 100000 /yr

Signalling equipment cost= $ 0
written-off over 40 years = $ 0 /yr

Gas detection equipment cost= $ 900000
written-off over 40 years = $ 22500 /yr

3. Platform truck for replacing lights etc.

Platform truck= $ 60000
written-off over 15 years = $ 4000.00 /yr

4. Platform truck maintenance and fuel

Allow $ 5000 /yr

Sub-total A - $ 875215 /yr

B. Mechanical Maintenance Costs

1. Labour (Assume equivalent of 1 mechanic/maintenance technician present at all times)

Mechanic 8736 hrs/yr @ 65 $/hr= $ 567840 /yr

2. Materials/replacement of equipment (assume mechanical equipment replaced every 40 years)

Ventilation equipment cost= $ 6000000
written-off over 40 years = $ 150000 /yr

3. Van for use by the mechanical/electrical maintenance staff (assume 1 no.)

Maintenance van= $ 25000
written-off over 8 years = $ 3125 /yr

Estimate of annual maintenance costs

B. Mechanical Maintenance Costs contd.

4. Van maintenance and fuel

Allow $ 5000 /yr

Sub-total B - $ 725965 /yr

C. Structure Maintenance Costs

1. Inspection (assume 3 man inspection crew for 5 weeks once every 4 years)

Senior engineer	50	hrs/yr @	130	$/hr=	$	6500	/yr
Engineer 1	50	hrs/yr @	80	$/hr=	$	4000	/yr
Engineer 2	50	hrs/yr @	80	$/hr=	$	4000	/yr

2. Tunnel cleaning and maintenance (assume 4 man crew on single shift basis throughout year)

Labourers	11648	hrs/yr @	50	$/hr=	$	582400	/yr

3. Street cleaner vehicle

Street cleaner vehicle= $ 65000
written-off over 15 years = $ 4333.333 /yr

4. Street cleaner vehicle maintenance and fuel

Allow $ 5000 /yr

5. Washer truck

Washing truck= $ 40000
written-off over 15 years = $ 2666.667 /yr

6. Washer truck maintenance and fuel

Allow $ 5000 /yr

Sub-total C - $ 613900 /yr

Total Maintenance Cost - $ 2215080 /yr

APPENDIX F

BREAKDOWN OF RAIL TUNNEL
OPERATING AND MAINTENANCE COSTS

Estimation of annual operating and maintenance costs

A. Energy Costs

1. Tunnel lighting	3000000	kWh/yr @	0.1	$/kWh=	$	300000	/yr
2. Ventilation fans	400000	kWh/yr @	0.1	$/kWh=	$	40000	/yr
3. Sump pumps	20000	kWh/yr @	0.1	$/kWh=	$	2000	/yr
				Sub-total A -	$	342000	/yr

B. Electrical Maintenance Costs

1. Labour (Assume 1 electricians for 5 days per week throughout year)

Electrician 1	2080	hrs/yr @	65	$/hr=	$	135200	/yr

2. Materials/replacement of equipment (assume electrical equipment replaced once every 40 years)

Electrical equipment cost= $ 1000000
written-off over 40 years = $ 25000 /yr

Sub-total B - $ 160200 /yr

C. Mechanical Maintenance Costs

1. Labour (Assume 1 mechanic/maintenance technician for 5 days per week throughout year)

Mechanic	2080	hrs/yr @	65	$/hr=	$	135200	/yr

2. Materials/replacement of equipment (assume mechanical equipment replaced every 40 years)

Ventilation system cost= $ 1000000
written-off over 40 years = $ 25000 /yr

Emergency generators= $ 500000
written-off over 40 years = $ 12500 /yr

Drainage pumps cost= $ 200000
written-off over 40 years = $ 5000 /yr

Sub-total C - $ 177700 /yr

contd.

Estimation of annual operating costs

D. Structure Maintenance Costs

1. Inspection (assume 3 man inspection crew for 10 weeks once every 4 years)

Senior engineer	100	hrs/yr @	130	$/hr=	$	13000	/yr
Engineer 1	100	hrs/yr @	100	$/hr=	$	10000	/yr
Engineer 2	100	hrs/yr @	100	$/hr=	$	10000	/yr

2. Tunnel Cleaning (Assume 4 man crew for 13 weeks once a year)

Labourers	2080	hrs/yr @	60	$/hr=	$	124800	/yr

3. Sump clean-up (Assume 2 man crew for 2 days twice a year)

Labourers	64	hrs/yr @	50	$/hr=	$	3200	/yr

4. Structure maintenance (Assume 4 man crew for 13 weeks once a year)

Labourers	2080	hrs/yr @	50	$/hr=	$	104000	/yr

5. Permanent Way Inspection (Assume 2 men inspect track 3 times per week)

Labourers	312	hrs/yr @	50	$/hr=	$	15600	/yr

6. Permanent way maintenance (Assume 4 man crew for 12 weeks once a year)

Labourers	1920	hrs/yr @	50	$/hr=	$	96000	/yr
				Sub-total D -	$	215600	/yr

Total estimated maintenance cost=$ 895,500 /yr

Newfoundland Fixed Link
Rail System - Estimation of Annual Operating Cost

	Item				*Annual Cost*
	Assumptions *Facility operates 12 hours/day, 7 days/week 50 percent of this time the facility is fully staffed with toll collectors. the remainder of the time only 1 toll booth is operating on each side*				
A	Salaried Staff	*Mult.*	*Unit*	*Rate*	
	Tunnel Manager	1.40	Year	100,000	140,000
	Tunnel Operator	1.40	Year	100,000	140,000
	Apprentice Operator	1.40	Year	60,000	84,000
	Site Maintenance Mgr	1.40	Year	50,000	70,000
B	Hourly Staff	*Quant*	*Unit*	*Rate*	
	Toll collectors - (2 FT, 4 PT, 1 PT Spare)	7,000	h	50	350,000
	Site Labor	4,000	h	35	140,000
	Electricians	6,000	h	65	390,000
	Mechanics	6,000	h	60	360,000
	Train drivers	8,000	h	85	680,000
	Loading foreman	4,000	h	55	220,000
	Laborers	20,000	h	40	800,000
C	Subcontracted Work				
	Locomotive maintenance	1	LS	120,000	120,000
	Rolling stock maintenance	1	LS	25,000	25,000
	Facility cleaning	52	w	250	13,000
	Landscaping	52	w	500	26,000
	Building maintenance	1	LS	10,000	10,000
D	Power	*Quant*	*Unit*	*Rate*	
		8,922	MW-h	60	535,324
E	Equipment Depreciation (straight-line)	*Life*	*Unit*	*Cap. Cost*	
	Locomotives (20 years)	20	Year	13,750,000	687,500
	Rolling stock (20 years)	20	Year	10,128,421	506,421
	Buildings	30	Year	2,912,000	97,067
	Roads	30	Year	1,250,000	41,667
	Trackwork	25	Year	3,130,000	125,200
	OCS system	15	Year	9,298,814	619,921
	Signal system	15	Year	6,592,000	439,467
	Train loading system	12	Year	500,000	41,667
	Heavy vehicles	12	Year	560,000	46,667
	Light trucks	7	Year	220,000	31,429

TOTAL ANNUAL OPERATING COST OF SHUTTLE TRAIN **$ 6,740,327**

Time	Train A	Train B	Train C	Track Use	PCUs to N	PCUs to L				
0:00:00	Loading at L	*Idle*	*Idle*	*unused*	0	0				
0:15:00	Departs for N	*Idle*	Loading at N	Train A	126		21	railcars with	6	ECU per c
0:30:00	Unloading at N	Loading at L	Departs for L	Train C		126				
0:45:00	Loading at N	Departs for N	Unloading at L	Train B	126					
1:00:00	Departs for L	Unloading at N	Loading at L	Train A		126				
1:15:00	Unloading at L	Loading at N	Departs for N	Train C	126					
1:30:00	Loading at L	Departs for L	Unloading at N	Train B		126				
1:45:00	Departs for N	Unloading at L	Loading at N	Train A	126					
2:00:00	Unloading at N	Loading at L	Departs for L	Train C		126				
2:15:00	Loading at N	Departs for N	Unloading at L	Train B	126					
2:30:00	Departs for L	Unloading at N	Loading at L	Train A		126				
2:45:00	Unloading at L	Loading at N	Departs for N	Train C	126					
3:00:00		Departs for L	Unloading at N	Train B		126				
3:15:00		Unloading at L								

252 PCU/hr
Each Direction

APPENDIX G

ECONOMIC ANALYSIS WORKBOOKS

ECONOMIC ANALYSIS WORKSHEETS - BASE CASE

Economic Methodology for Fixed Link Project

Section 1 - Transportation Economies

				Phase 1 - Planning Approval			Phase 2 - Design & Construction																	
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Traffic	Travellers																							
	(one-way trips)	Tourist Visitors - ferry/link	3.50%	13,000	13,455	13,926	14,413	14,918	15,440	15,980	16,540	17,119	17,718	18,338	18,980	19,644	20,331	21,043	21,780	22,542	23,331	24,147	24,993	25,867
		Traditional Tourist Vehicles		4,869	5,039	5,216	5,398	5,587	5,783	5,985	6,195	6,411	6,636	6,868	7,108	7,357	7,615	7,881	8,157	8,443	8,739	9,044	9,360	9,680
		Induced Visitors - fixed Link	1.25%												229	477	746	1,035	1,347	1,684	2,045	2,434	2,852	3,299
		Induced Demand Vehicles - Tourists	2.67												86	179	279	388	505	631	766	912	1,068	1,236
		Tourist Vehicle - ferry/link	2.67	4,869	5,039	5,216	5,398	5,587	5,783	5,985	6,195	6,411	6,636	6,868	7,194	7,536	7,894	8,269	8,662	9,073	9,504	9,956	10,429	10,924
	Passenger Veh																							
	Labrador	Local and Business Traffic Base	1.5%	16,769	17,139	17,510	17,903	18,297	18,690	19,100	19,526	19,952	20,387	20,830	27,079	27,485	27,898	28,316	28,741	29,172	29,610	30,054	30,505	30,962
		one-time surge	30.0%																					
	Cabot	Diverted Passenger Vehicles													20,334	20,842	21,363	21,897	22,445	23,006	23,581	24,170	24,775	25,394
		Induced Demand Veh %	1.50%												6,100	6,192	6,284	6,379	6,474	6,577	6,670	6,770	6,872	6,975
		One time effect	30.0%																					
	Total	Total Passenger Vehicles													60,793	62,734	63,718	65,289	66,876	68,453	70,131	71,861	73,647	75,490
		Total Induced Vehicle Trips		0	0	0	0	0	0	0	0	0	0	0	6,186	6,370	6,564	6,766	6,979	7,202	7,436	7,682	7,940	8,211
		Total Visitors	2.67												167,318	170,164	173,170	174,714	178,416	182,769	187,249	191,870	196,638	201,559
	Base Freight																							
		Cabot/Oceanex Tractor-trailer	2.50%	142,402	145,962	149,611	153,351	157,185	161,115	165,143	169,271	173,503	177,841	182,287	186,844	191,515	196,303	201,210	206,241	211,397	216,681	222,099	227,651	233,342
		Apollo Tractor-trailer		2,404	2,464	2,526	2,589	2,654	2,720	2,788	2,858	2,929	3,003	3,078	3,155	3,233	3,314	3,397	3,482	3,569	3,658	3,750	3,843	3,940
		Diverted Cabot/Oceanex Tractor-Trailer	10%												18,684	19,151	19,630	20,121	20,624	21,140	21,668	22,210	22,765	23,334
		Induced Cabot/Oceanex Tractor-Trailer	1.0%												1,868	1,915	1,963	2,012	2,062	2,114	2,167	2,221	2,277	2,333
		Total Tractor-trailer													23,707	24,300	24,908	25,530	26,168	26,823	27,493	28,181	28,885	29,607
	Design Peak Hour Vol	Autos													38	39	40	41	42	43	44	45	46	47
		Trucks													8	9	9	9	9	9	10	10	10	10
		PCUs	2.5												59	60	62	63	65	67	68	70	72	73
		Dominant Direction (ratio)	50.00%												29	30	31	32	32	33	34	35	36	37
Revenues Total															6,692,243	6,855,814	7,023,848	7,196,483	7,373,863	7,556,135	7,743,454	7,935,975	8,133,874	8,337,312
	Passenger Tolls														1,015,241	1,039,365	1,064,098	1,089,033	1,115,998	1,143,164	1,171,183	1,200,081	1,229,913	1,260,690
	Vehicle Tolls														1,874,190	1,898,117	1,941,413	1,990,185	2,039,205	2,087,811	2,158,986	2,191,775	2,246,244	2,302,458
	Freight Tolls														3,812,808	3,918,378	4,016,337	4,116,746	4,219,664	4,325,156	4,433,285	4,544,117	4,657,720	4,774,163
	Other																							
Expenses Total															4,555,581	4,555,581	4,555,581	4,555,581	4,555,581	4,555,581	4,775,581	4,555,581	4,555,581	4,966,206
	Operations																							
		Wages													3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000
		Energy													481,581	481,581	481,581	481,581	481,581	481,581	481,581	481,581	481,581	892,206
	Annual Maintenance																							
		Wages													614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000
		Purchased Serv & Supp													86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000
	Periodic Maintenance																							
		Purchased Serv & Supp																			220,000			
Gross Operating (Surplus/Deficit)															2,136,662	2,300,233	2,468,267	2,640,902	2,818,282	3,000,554	2,967,873	3,380,394	3,578,293	3,371,106
OperatingCostFact	100%																							
Total Capital Investment (Outflow)	Pre-operation		1,184,466,303	11,000,000	2,000,000	2,000,000	24,975,000	24,975,000	143,684,647	216,789,022	254,041,183	182,458,739	188,557,044	133,985,669										
	Operations Phase	Revenues	0												0	0	0	0	0	0	0	0	0	0
		Costs																						
	Infrastructure																							
		Civil Works	971,746,540	11,000,000	2,000,000	2,000,000	24,975,000	24,975,000	121,888,283	194,992,658	232,244,820	160,662,375	130,483,833	84,318,332										
		M & E	17,004,000		0	0	0	0	0	0	0	0	10,627,500	6,376,500										
		Systems	29,672,471		0	0	0	0	0	0	0	0	19,761,648	9,910,823										
		Rolling Stock	37,367,772	0	0	0	0	0	0	0	0	0	0	37,367,772										
	Sub total		1,055,784,783																					
	Other (Design, Proj. Mgt)		128,681,520	0	0	0	0	0	21,796,364	21,796,364	21,796,364	21,796,364	27,664,044	13,832,022										
TOTAL CAPEX		$ 2004	1,184,466,303																					
CapCostFactor	100%																							
Present Values at Social Discount Rate	Present Value Income Operation Phase		49,957,013												2,809,766	2,677,610	2,551,859	2,432,067	2,318,247	2,209,814	2,106,601	2,008,311	1,914,821	1,825,779
	Present Value Costs Operating Phase		-30,867,079												1,912,679	1,778,237	1,653,196	1,539,632	1,432,315	1,332,293	1,239,104	1,152,077	1,072,444	1,087,544
	Present Value Capital Investment		-667,012,930	-10,232,558	-1,730,665	-1,609,921	-18,701,293	-17,396,552	-95,102,122	-130,670,645	-142,441,650	-95,107,463	-91,486,733	-60,473,519										
	Net Present Value of Fixed Link Cash Flows		-647,922,996																					
Benefit Cost Ratio and IRR	Fixed Link Cash Flows	sum undiscounted	-1,093,062,657	-11,000,000	-2,000,000	-2,000,000	-24,975,000	-24,975,000	-143,684,647	-216,789,022	-254,041,183	-182,458,739	-188,557,044	-133,985,669	2,136,662	2,300,233	2,468,267	2,640,902	2,818,282	3,000,554	2,967,873	3,380,394	3,578,293	3,371,106
	Real Internal Rate of Return (RIRR)		-9.83%																					
	Benefit /Cost Ratio		0.07																					

Indirect Transportation

				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Marine Atlantic Impacts	Passenger Vehicles																							
		Base Projection # Vehicle trips	2.50%	154,972	158,846	162,817	166,888	171,060	175,337	179,720	184,212	188,818	193,539	198,377	203,337	208,420	213,631	218,971	224,446	230,057	235,808	241,703	247,746	253,940
		Vehicle trips diverted	10%												-20,334	-20,842	-21,363	-21,897	-22,445	-23,006	-23,581	-24,170	-24,775	-25,394
		Net Vehicle trips													183,003	187,578	192,268	197,074	202,001	207,051	212,227	217,533	222,971	228,546
		Passenger Vehicle Revenue $	148	22,935,856	23,509,252	24,096,984	24,699,400	25,316,884	25,949,810	26,598,561	27,263,525	27,945,113	28,643,741	29,359,835	27,084,438	27,761,539	28,455,598	29,166,988	29,896,162	30,643,566	31,409,650	32,194,897	32,999,769	33,824,764
	Freight tractor trailer																							
		Base Projection Tractor trailer	2.5	94,935	97,308	99,741	102,234	104,790	107,410	110,095	112,847	115,669	118,560	121,524	124,563	127,677	130,868	134,140	137,494	140,931	144,454	148,066	151,767	155,562
		Diverted Freight tractor trailer	1												-18,684	-19,151	-19,630	-20,121	-20,624	-21,140	-21,668	-22,210	-22,765	-23,334
		Net Freight tractor trailer													105,878	108,525	111,238	114,019	116,870	119,791	122,786	125,856	129,002	132,227
		Net Revenue $	257.25	24,421,943	25,032,492	25,658,304	26,299,761	26,957,255	27,631,187	28,321,967	29,030,016	29,755,766	30,499,660	31,262,152	27,237,150	27,918,079	28,616,029	29,331,431	30,064,717	30,816,335	31,586,743	32,376,412	33,185,822	34,015,468
		Change in Pass. Car Equivalent Vol (PCU)			2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.6%	2.6%	11.1%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%

Economic Methodology for Fixed Link Project				Phase 1 - Planning Approval			Phase 2 - Design & Construction																	
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	Total Operating Cost		111	111,100,000	112,319,750	113,554,325	114,803,907	116,068,686	117,348,848	118,644,585	119,956,092	121,283,563	122,660,789	124,090,048	117,989,626	119,293,109	120,612,437	121,947,887	123,299,540	124,667,677	126,052,482	127,454,164	128,872,932	130,308,999
		Wages	64.3	64,300,000	65,103,750	65,917,547	66,741,516	67,575,785	68,420,482	69,275,739	70,141,686	71,018,456	71,928,300	72,873,002	68,830,843	69,700,341	70,571,595	71,453,740	72,340,912	73,251,248	74,166,889	75,093,975	76,032,649	76,983,058
		Fuel	16.9	16,900,000	16,942,250	16,984,606	17,027,067	17,069,635	17,112,309	17,155,090	17,197,977	17,240,972	17,285,152	17,330,533	17,138,721	17,181,508	17,224,522	17,267,583	17,310,752	17,354,029	17,397,414	17,440,907	17,484,510	17,528,221
		Purchased Goods & Ser	29.9	29,900,000	30,273,750	30,652,172	31,035,324	31,423,266	31,816,056	32,213,757	32,616,429	33,024,134	33,447,336	33,886,513	32,011,062	32,411,260	32,816,340	33,226,545	33,641,876	34,062,400	34,488,180	34,919,283	35,355,773	35,797,720
	Subsidy impact	-- reference subsidy $mm	43.8																					
		Incremental gain (loss)													-1,715,497	-8,583,767	-8,791,018	-9,003,362	-8,627,334	-8,843,017	-9,064,093	-9,290,695	-9,572,963	-9,761,057
	Net Revenue	Operating Surplus(deficit)		-63,742,201	-63,778,006	-63,799,037	-63,804,738	-63,794,537	-63,767,845	-63,724,057	-63,662,551	-63,582,684	-63,517,387	-63,468,081	-63,668,028	-62,309,988	-63,540,829	-63,449,440	-63,358,661	-63,207,775	-63,056,083	-62,882,855	-62,687,341	-62,468,767
	Capital Plan - Base	$ Millions					75			100					150		150		150					
	Capital Plan - Divert	$ Millions					75			100													300	
	Total Cash - Base			-63,742,201	-63,778,006	-63,799,037	-138,804,738	-63,794,537	-63,767,845	-163,724,057	-63,662,551	-63,582,684	-63,517,387	-63,468,081	-211,952,532	-53,726,211	-204,749,811	-54,446,080	-204,711,326	-54,364,758	-53,991,990	-53,592,160	-53,164,378	-52,707,731
	Total Cash - Divert			-63,742,201	-63,778,006	-63,799,037	-138,804,738	-63,794,537	-63,767,845	-163,724,057	-63,662,551	-63,582,684	-63,517,387	-63,468,081	-63,668,028	-62,309,988	-63,540,829	-63,449,440	-63,358,661	-63,207,775	-63,056,083	-62,882,855	-362,687,341	-62,468,767
	PV Base (2004)		-1,044,206,083	-59,295,071	-55,189,189	-51,355,709	-103,937,061	-44,436,635	-41,319,110	-98,685,478	-35,695,734	-33,163,677	-30,818,251	-28,645,886	-88,989,146	-20,983,419	-74,388,364	-18,630,927	-64,358,579	-15,899,137	-14,688,484	-13,567,522	-12,515,594	-11,542,412
	PV Divert		-1,015,598,330	-59,295,071	-55,189,189	-51,355,709	-103,937,061	-44,436,635	-41,319,110	-98,685,478	-35,695,734	-33,163,677	-30,818,251	-28,645,886	-26,731,285	-24,335,912	-23,085,239	-21,443,758	-19,912,851	-18,485,305	-17,154,365	-15,913,710	-85,381,360	-13,679,971
	Net Present Value	Benefit attributable to fixed link	28,607,753																					
Apollo Impacts																								
	Base																							
		Total Vehicles #	2.50%	24042	24643	25259	25891	26538	27201	27881	28578	29293	30025	30776										
		Trucks # (est.)	10.00%	2,404	2,464	2,526	2,589	2,654	2,720	2,788	2,858	2,929	3,003	3,078										
		Passenger Vehicles #		21,638	22,179	22,733	23,302	23,884	24,481	25,093	25,721	26,364	27,023	27,698										
	Subsidy impact	Reference Annual Subsidy $ millions	5.5																					
		Sub total																						
	Net Change	Surplus(deficit)		-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000 0	-5,500,000 0	-5,500,000 0	-5,500,000 0	-5,500,000 0	-5,500,000 0	-5,500,000 0	-5,500,000 0	-5,500,000 0	-5,500,000 0
	Capital Plan - Base												75											
	Capital Plan - Divert												20											
	Total Cash - Base			-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-80,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000
	Total Cash - Divert			-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-25,500,000	-5,500,000	0	0	0	0	0	0	0	0	0	0
	PV Base (2004)		-110,098,784	-5,116,279	-4,759,329	-4,427,283	-4,118,403	-3,831,072	-3,563,788	-3,315,152	-3,083,862	-2,868,709	-39,058,111	-2,482,388	-2,309,198	-2,148,091	-1,998,224	-1,858,813	-1,729,128	-1,608,492	-1,496,271	-1,391,880	-1,294,772	-1,204,439
	PV Divert		-49,938,711	-5,116,279	-4,759,329	-4,427,283	-4,118,403	-3,831,072	-3,563,788	-3,315,152	-3,083,862	-2,868,709	-12,372,445	-2,482,388	0	0	0	0	0	0	0	0	0	0
	Net Present Value	Benefit attributable to fixed link	60,160,073																					
Transportation Net Present Value - ERR and Benefit to Cost Ratio	Fix Link Cash Flows			-11,000,000	-2,000,000	-2,000,000	-24,975,000	-24,975,000	-143,684,647	-210,789,022	-254,041,183	-182,458,739	-188,557,044	-133,985,669	2,130,667	2,300,233	2,468,267	2,640,902	2,818,282	3,000,554	2,967,873	3,380,398	3,578,293	3,371,106
	Marine Atlantic Economic Benefit			0	0	0	0	0	0	0	0	0	0	0	148,284,503	-8,583,767	141,208,982	-9,003,362	141,372,666	-8,843,017	-9,064,093	-9,290,695	-309,572,963	-9,761,057
	Apollo Economic Benefit			0	0	0	0	0	0	0	0	0	55,000,000	0	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000
	Total Economic Cash Flow		-878,841,338	-11,000,000	-2,000,000	-2,000,000	-24,975,000	-24,975,000	-143,684,647	-210,789,022	-254,041,183	-182,458,739	-133,557,044	-133,985,669	153,921,160	-783,534	149,177,249	-862,460	149,690,947	-342,464	-596,220	-410,298	-300,444,669	-889,951
		Present Value	-550,155,170	-10,232,558	-1,730,665	-1,609,921	-18,701,293	-17,390,552	-93,102,122	-130,670,645	-142,441,459	-95,167,403	-64,801,007	-60,473,510	63,464,145	-306,010	56,190,104	-291,492	47,060,887	-100,154	-162,201	-103,834	-70,728,625	-194,885
	Economic Net Present Value		-559,155,170																					
	Economic Rate of Return (ERR)		-5.28%																					
	Benefit /Cost Ratio		0.19																					
Other Economic Impacts			-311,649,822		-1,405,340	-1,405,340	-17,549,183	-17,549,183	-107,443,683	-158,811,855	-184,987,831	-134,588,995	-91,600,405	-112,311,783	165,007,920	8,458,361	158,177,689	8,780,024	159,419,093	9,333,051	9,301,489	9,837,531	-290,015,665	8,787,291
	Construction Impacts	Indirect plus induced GDP -- NPV	166,971,243																					
	Operations Impacts	Indirect plus induced GDP -- NPV	4,350,097																					
	Tourism Impacts	Total GDP Impact -- NPV	54,374,372																					
	Total Spin-off Benefits	NPV	225,695,712																					
	Fixed Link Economic NPV		-333,459,458																					
		Socio-economic Rate of Return	-1.4%																					
		Benefit Cost Ratio	0.92																					
	SECTION 2 - Financial Analysis																							
		Project Cost, Constant 2004$		-11,000,000	-2,000,000	-2,000,000	-24,975,000	-24,975,000	-143,684,647	-210,789,022	-254,041,183	-182,458,739	-188,557,044	-133,985,669	2,130,662	2,300,233	2,468,267	2,640,902	2,818,262	3,000,554	2,967,873	3,380,398	3,578,293	3,371,106
		Nominal Value		-11,275,000	-2,101,250	-2,153,781	-27,567,727	-28,256,920	-166,630,139	-257,694,022	-309,524,514	-227,865,962	-241,368,958	-175,800,800	2,873,573	3,170,897	3,487,597	3,824,814	4,183,795	4,563,698	4,828,569	5,404,073	5,865,450	5,062,048
Financing during Construction	Cumm. Const. Cost	Comprised of:	-1,707,787,952	-11,275,000	-13,658,125	-16,442,261	-44,778,278	-74,584,919	-244,237,880	-509,978,042	-838,559,100	-1,100,614,912	-1,391,317,967	-1,630,650,450										
		Interest during Construction (IDC)	-257,548,871	-281,875	-630,375	-768,270	-1,549,721	-3,022,023	-8,046,141	-19,056,552	-34,189,843	-49,554,087	-63,531,674	-77,137,502										
		Project Costs	-1,450,239,081																					
Financing Base Case	Project Cost																							
Debt Financing		Pre operations cost	1,450,239,081																					
		Interest during Construction	257,548,871																					
	Total Amount to Finance		1,707,787,952																					
		Annual Debt Amortization (CRF)	-188,759,209												-188,759,209	-188,759,209	-188,759,209	-188,759,209	-188,759,209	-188,759,209	-188,759,209	-188,759,209	-188,759,209	-188,759,209
		Net Cash Flow													-185,885,636	-185,588,312	-185,271,612	-184,934,395	-184,575,454	-184,195,511	-184,130,340	-183,355,136	-182,895,759	-183,097,161
		IRR Excl IDC	-7.2%																					
Subsidized Financing Sensitivity Case		Project Spending	1,450,239,081	11,275,000	2,101,250	2,153,781	27,567,727	28,256,920	166,630,139	257,694,022	309,524,514	227,865,962	241,368,958	173,800,000										
		Grant Award	1,395,000,000	11,275,000	2,101,250	2,153,781	27,567,727	28,256,920	166,630,139	257,694,022	309,524,514	227,865,962	241,368,958	120,561,720										
		Cost less Grant	55,239,081	0	0	0	0	0	0	0	0	0	0	55,239,081										
	Total Amount to Finance		56,620,058																					
		Comprised of:		0	0	0	0	0	0	0	0	0	0	55,239,081										
		Interest during Construction (IDC)	1,380,977	0	0	0	0.00	0	0	0	0	0	0	1,380,977										

Economic Methodology for Fixed Link Project

				Phase 1 - Planning Approval			Phase 2 - Design & Construction																	
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
		Project Costs	55,239,081																					
		Internal Rate of Return	8.0%	0	0	0	0	0	0	0	0	0	0	-56,620,058	2,873,573	3,170,897	3,487,597	3,824,814	4,183,755	4,365,698	4,628,869	5,404,073	5,863,450	5,662,048

Section 3 - Socio-Economic Impact

				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Construction Effects																								
	Construction Spending	Annual Civil & M&E		11,000,000	2,000,000	2,000,000	24,975,000	24,975,000	121,888,283	194,992,658	232,244,820	160,662,375	141,111,353	72,895,052										
		Direct GDP	34.0%	3,740,000	680,000	680,000	8,491,500	8,491,500	41,442,016	66,297,504	78,963,239	54,625,207	47,977,860	24,784,318										
		Indirect	63.0%	2,356,200	428,400	428,400	5,349,645	5,349,645	26,108,470	41,767,427	49,746,840	34,413,881	30,226,052	15,614,120										
		Induced	15.0%	914,430	166,260	166,260	2,076,172	2,076,172	10,132,573	16,209,740	19,306,512	13,355,863	11,730,587	6,059,766										
		Indirect plus induced GNP impact		3,270,630	594,660	594,660	7,425,817	7,425,817	36,241,043	57,977,167	69,053,352	47,769,744	41,956,638	21,673,886										
		Net Present Value	166,971,243	3,042,447	514,579	478,678	5,560,456	5,172,517	23,482,801	34,946,022	38,718,369	24,915,909	20,357,106	9,782,361										
Operations Impacts	Operations Costs	Annual Costs													4,555,581	4,555,581	4,555,581	4,555,581	4,555,581	4,555,581	4,775,581	4,555,581	4,555,581	4,966,206
		Direct GDP	34.0%												1,548,898	1,548,898	1,548,898	1,548,898	1,548,898	1,548,898	1,623,698	1,548,898	1,548,898	1,688,510
		Indirect	23.0%												356,246	356,246	356,246	356,246	356,246	356,246	373,450	356,246	356,246	388,357
		Induced	15.0%												285,772	285,772	285,772	285,772	285,772	285,772	299,572	285,772	285,772	311,539
		Indirect plus induced GNP impact													642,018	642,018	642,018	642,018	642,018	642,018	673,023	642,018	642,018	699,887
		Net Present Value	4,350,097												269,554	250,748	233,254	216,989	201,842	187,760	183,095	162,475	151,139	153,268
Tourism Impacts	Tourist Indicators																							
		Induced Visitors -- trip add on	1												54,520	56,126	57,785	59,500	61,274	63,109	65,006	66,969	69,000	71,101
		Induced Visitors -- full trip	11												16,287	16,532	16,780	17,031	17,287	17,546	17,809	18,076	18,347	18,623
		Incremental Room nights	2	6,500	6,720	6,963	7,207	7,459	7,720	7,990	8,270	8,559	8,859	9,169	116,840	118,986	121,180	123,422	125,714	128,057	130,454	132,904	135,411	137,976
		Incre. Annual Expenditures Tourists	62.35												14,569,953	14,837,609	15,111,147	15,390,735	15,676,547	15,968,765	16,267,575	16,573,173	16,885,760	17,205,547
		Direct GDP	35.0%												5,099,484	5,193,163	5,288,902	5,386,757	5,486,792	5,589,068	5,693,651	5,800,610	5,910,016	6,021,941
		Indirect	44.0%												2,243,773	2,284,992	2,327,117	2,370,173	2,414,188	2,459,190	2,505,207	2,552,269	2,600,407	2,649,654
		Induced	15.0%												1,101,488	1,121,723	1,142,403	1,163,540	1,185,147	1,207,239	1,229,829	1,252,932	1,276,563	1,300,739
		Total													8,444,745	8,599,878	8,758,421	8,920,470	9,086,127	9,255,496	9,428,686	9,605,811	9,786,987	9,972,335
		Net Present Value	54,[illegible]172												3,545,561	3,358,786	3,182,052	3,014,816	2,856,560	2,706,798	2,565,068	2,430,934	2,303,985	2,183,831
TOTAL OTHER IMPACTS		Net Present Value - Real	225,695,713	3,042,447	514,579	478,678	5,560,456	5,172,517	23,482,801	34,946,022	38,718,369	24,915,909	20,357,106	9,782,361	3,815,115	3,609,533	3,415,306	3,231,796	3,058,402	2,894,558	2,748,163	2,593,409	2,455,125	2,337,099
Social Impacts																								
	Employment	Construction & Operations																						
		NL - Skilled		0	0	0	0	0	192	229	257	201	247	182	25	25	25	25	25	25	25	25	25	25
		NL - Unskilled		0	0	0	0	0	166	231	278	184	202	102	15	15	15	15	15	15	15	15	15	15
		Non NL		0	0	0	0	0	0	19	29	24	4	2	0	0	0	0	0	0	0	0	0	0
		Total NL Direct Employment		0	0	0	0	0	358	462	535	385	449	284	40	40	40	40	40	40	40	40	40	40
		Indirect Construction Employment	0.63	0	0	0	0	0	226	291	337	243	283	179	25	25	25	25	25	25	25	25	25	25
		Induced Construction Employment	0.3	0	0	0	0	0	175	226	262	188	220	139	20	20	20	20	20	20	20	20	20	20
		Total Annual FTE Employment		0	0	0	0	0	759	979	1,134	816	951	602	85	85	85	85	85	85	85	85	85	85
		Tourism																						
		Total Incremental Spending													14,569,953	14,837,609	15,111,147	15,390,735	15,676,547	15,968,765	16,267,575	16,573,173	16,885,760	17,205,547
		Incremental FTE - Direct	12.8												186	190	193	197	201	204	208	212	216	220
		Incremental FTE - Indirect	0.24																					
		Incremental FTE - Induced	0.15																					
		Total Impact	18.3												266	271	276	281	286	291	297	303	308	314
		TOTAL RELATED EMPLOYMENT			0	0	0	0	759	979	1,134	816	951	602	351	356	361	366	371	376	383	387	393	399
	Wages	Construction & Operations																						
		Direct Payroll		3,300,000	600,000	600,000	7,492,500	7,492,500	36,566,485	58,497,797	69,673,446	48,198,712	42,333,406	21,868,515	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000
		Indirect Construction Employment	0.53	1,749,000	318,000	318,000	3,971,025	3,971,025	19,380,237	31,003,833	36,926,926	25,545,318	22,436,705	11,590,313	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640
		Induced Construction Employment	0.3	1,514,700	275,400	275,400	3,439,058	3,439,058	16,784,017	26,850,489	31,980,112	22,123,209	19,431,033	10,037,649	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492
		Sub-Total Wages		6,563,700	1,193,400	1,193,400	14,902,583	14,902,583	72,730,738	116,352,119	138,580,484	95,867,239	84,201,144	43,496,477	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132
		Tourism																						
		Incremental Direct Wages	23.6%												3,438,309	3,501,676	3,566,231	3,632,214	3,699,665	3,768,628	3,839,148	3,911,269	3,985,039	4,060,509
		Incremental Indirect Wages	33.0%																					
		Incremental Induced Wages	15.0%																					
		Sub-Total Wages	36.1%												5,250,199	5,355,813	5,454,550	5,555,471	5,658,638	5,764,117	5,871,976	5,982,286	6,095,118	6,210,549
		TOTAL RELATED WAGES		6,563,700	1,193,400	1,193,400	14,902,583	14,902,583	72,730,738	116,352,119	138,580,484	95,867,239	84,201,144	43,496,477	13,191,331	13,287,945	13,386,682	13,487,603	13,590,770	13,696,249	13,804,108	13,914,418	14,027,250	14,142,681
		NPV Wages	411,333,783	6,105,767	1,032,888	960,640	11,159,062	10,380,522	47,126,720	70,131,810	77,702,387	50,003,768	40,853,884	19,631,839	5,530,436	5,189,766	4,863,563	4,558,351	4,272,761	4,005,509	3,755,398	3,521,310	3,302,199	3,097,091
	Other Impacts																							

Economic Methodology for Fixed Link Project

Section 1 - Transportation Economics

Phase 3 - Operation

				22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Traffic	Travellers																						
	(one way trips)	Tourist Visitors - ferry/link	3.50%	26,773	27,710	28,679	29,683	30,722	31,797	32,910	34,062	35,254	36,488	37,765	39,087	40,455	41,871	43,337	44,853	46,423	48,048	49,730	51,470
		Traditional Tourist Vehicles		10,027	10,378	10,741	11,117	11,506	11,909	12,326	12,757	13,204	13,666	14,144	14,639	15,152	15,683	16,231	16,790	17,387	17,996	18,625	19,277
		Induced Visitors - fixed Link	1.25%	3,780	4,294	4,844	5,433	6,062	6,734	7,451	8,216	9,032	9,902	10,828	11,815	12,869	13,981	15,169	16,431	17,772	19,197	20,709	22,315
		Induced Demand Vehicles - Tourist	2.67	1,416	1,608	1,814	2,035	2,270	2,522	2,791	3,077	3,383	3,709	4,056	4,425	4,818	5,236	5,681	6,154	6,656	7,190	7,756	8,358
		Tourist Vehicles - ferry/link	2.67	11,443	11,986	12,556	13,152	13,777	14,431	15,117	15,835	16,587	17,375	18,200	19,064	19,970	20,919	21,912	22,953	24,043	25,185	26,382	27,635
	Passenger Veh																						
	Labrador	Local and Business Traffic Base	1.5%	31,427	31,898	32,376	32,862	33,355	33,855	34,363	34,879	35,402	35,933	36,472	37,019	37,574	38,138	38,710	39,290	39,880	40,478	41,085	41,701
		one time surge	30.0%																				
	Cabot	Diverted Passenger Vehicles		26,020	26,680	27,347	28,030	28,731	29,449	30,185	30,940	31,714	32,506	33,319	34,152	35,006	35,881	36,778	37,697	38,640	39,606	40,596	41,611
		Induced Demand Veh %	1.50%	7,079	7,186	7,293	7,403	7,514	7,627	7,741	7,857	7,975	8,095	8,216	8,339	8,464	8,591	8,720	8,851	8,984	9,118	9,255	9,394
		One time effect	30.0%																				
	Total	Total Passenger Vehicles		77,303	79,557	81,386	83,482	85,647	87,884	90,197	92,588	95,060	97,617	100,262	103,000	105,832	108,765	111,801	114,946	118,203	121,578	125,074	128,699
		Total Induced Vehicle Trips		8,495	8,794	9,108	9,437	9,784	10,149	10,532	10,934	11,358	11,803	12,272	12,764	13,283	13,828	14,401	15,005	15,640	16,308	17,011	17,752
		Total Visitors	2.67	206,639	211,884	217,301	222,896	228,677	234,651	240,825	247,209	253,810	260,637	267,700	275,009	282,573	290,403	298,510	306,905	315,602	324,612	333,949	343,626
	Base Freight																						
		Cabot/Oceanex Tractor trailer	2.50%	239,176	245,155	251,284	257,566	264,005	270,605	277,371	284,305	291,413	298,698	306,165	313,819	321,665	329,707	337,949	346,398	355,058	363,934	373,033	382,358
		Apollo Tractor trailer		4,038	4,139	4,242	4,349	4,457	4,569	4,683	4,800	4,920	5,043	5,169	5,298	5,431	5,567	5,706	5,848	5,995	6,144	6,298	6,455
		Diverted Cabot/Oceanex Tractor-Trailer	10%	23,918	24,516	25,128	25,757	26,401	27,061	27,737	28,430	29,141	29,870	30,617	31,382	32,166	32,971	33,795	34,640	35,506	36,393	37,303	38,236
		Induced Cabot/Oceanex Tractor Trailer	1.0%	2,392	2,452	2,513	2,576	2,640	2,706	2,774	2,843	2,914	2,987	3,062	3,138	3,217	3,297	3,379	3,464	3,551	3,639	3,730	3,824
		Total Tractor trailer		30,347	31,106	31,884	32,681	33,498	34,335	35,194	36,074	36,975	37,900	38,847	39,818	40,814	41,834	42,880	43,952	45,051	46,177	47,332	48,515
	Design Peak Hour Vol	Autos		48	50	51	52	54	55	56	58	59	61	63	64	66	68	70	72	74	76	78	80
		Trucks		11	11	11	12	12	12	12	13	13	13	14	14	14	15	15	16	16	16	17	17
		PCUs	2.5	75	77	79	81	83	85	86	90	93	95	97	100	102	105	108	111	114	117	120	123
		Dominant Direction (ratio)	50.00%	38	39	40	41	42	43	44	45	46	47	49	50	51	53	54	55	57	58	60	62
Revenues Total				8,546,408	8,761,926	8,982,677	9,210,118	9,444,054	9,684,696	9,932,264	10,186,987	10,449,102	10,718,854	10,996,498	11,282,298	11,576,530	11,879,478	12,191,438	12,512,717	12,843,636	13,184,524	13,535,728	13,897,604
	Passenger Tolls			1,292,463	1,323,269	1,359,140	1,394,146	1,430,301	1,467,666	1,506,285	1,546,212	1,587,500	1,630,204	1,674,381	1,720,093	1,767,403	1,816,376	1,867,083	1,919,596	1,973,990	2,030,345	2,088,742	2,149,269
	Vehicle Tolls			2,360,487	2,420,402	2,482,277	2,546,191	2,612,226	2,680,465	2,751,000	2,823,921	2,899,327	2,977,318	3,058,001	3,141,487	3,227,891	3,317,334	3,409,943	3,505,849	3,605,192	3,708,115	3,814,769	3,925,312
	Freight Tolls			4,893,517	5,015,855	5,141,251	5,269,783	5,401,527	5,536,565	5,674,980	5,816,854	5,962,275	6,111,332	6,264,116	6,420,718	6,581,236	6,745,767	6,914,412	7,087,272	7,264,454	7,446,065	7,632,217	7,823,022
	Other																						
Expenses Total				4,966,206	6,026,206	4,966,206	4,966,206	4,966,206	20,788,206	4,966,206	4,966,206	4,966,206	28,844,206	4,966,206	4,966,206	4,966,206	4,966,206	8,096,206	4,966,206	4,966,206	4,966,206	4,966,206	10,828,206
	Operations																						
		Wages		3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000
		Energy		892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206
	Annual Maintenance																						
		Wages		614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000
		Purchased Serv & Supp		86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000
	Periodic Maintenance																						
		Purchased Serv & Supp			1,060,000				15,822,000				23,878,000					3,130,000					5,862,000
Gross Operating (Surplus/Deficit)				3,580,202	2,735,720	4,016,471	4,243,912	4,477,848	-11,103,510	4,966,058	5,220,781	5,482,896	-18,125,352	6,030,292	6,316,092	6,610,324	6,913,272	4,095,232	7,546,511	7,877,430	8,218,318	8,569,522	3,069,398
OperatingCostFact	100%																						
Total Capital Investment (Outflow)	Pre-operation		1,184,466,303																				
	Operations Phase	Revenues	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Costs																					
	Infrastructure																						
		Civil Works	971,760,540																				
		M & E	17,054,000																				
		Systems	39,677,471																				
		Rolling Stock	27,307,772																				
	Sub total		1,055,799,783																				
	Other (Design, Proj. Mgt)		128,666,520																				
TOTAL CAPEX		$ 2004	1,184,466,303																				
CapCostFactor	100%																						
Present Values at Social Discount Rate	Present Value Income Operations Phase		45,957,013	1,761,097	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Present Value Costs Operating Phase		-30,867,079	1,011,600	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Present Value Capital Investment		-663,017,930																				
	Net Present Value of Fixed Link Cash Flows		-647,927,996																				
Benefit Cost Ratio and IRR	Fixed Link Cash Flows	con undiscounted	-1,005,067,617	3,580,202	2,735,720	4,016,471	4,243,912	4,477,848	-11,103,510	4,966,058	5,220,781	5,482,896	-18,125,352	6,030,292	6,316,092	6,610,324	6,913,272	4,095,232	7,546,511	7,877,430	8,218,318	8,569,522	3,069,398
	Real Internal Rate of Return (RIRR)		-0.53%																				
	Benefit /Cost Ratio		0.67																				

Indirect Transportation

				22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Marine Atlantic Impacts																							
	Passenger Vehicle																						
		Base Projection # Vehicle trips	2.50%	266,788	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Vehicle trips diverted	10%	-26,979	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Net Vehicle trips		234,790	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Passenger Vehicle Revenue $	148	34,670,981	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Freight tractor trailer																						
		Base Projection Tractor-trailer	2/3	150,451	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Diverted Freight tractor-trailer	1	-23,918	-24,516	-25,128	-25,757	-26,401	-27,061	-27,737	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Net Freight tractor trailer		135,533	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Net Revenue $	257.75	34,865,054	35,737,501	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Change in Pass. Car Equivalent Vols (PCU)		2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Economic Methodology for Fixed Link Project

Phase 3 - Operation

				22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
	Vessel Operating Cost		101	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Wages	64.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Fuel	16.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Purchased Goods & Ser	29.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Subsidy Impact	– reference subsidy [illegible]	[illegible]																				
		Incremental gain (loss)		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Net Revenue	Operating Surplus(deficit)		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Capital Plan - Base	$ M Base																					
	Capital Plan - Divgt	$ M Base		[illegible]																			
	Total Cash - Base			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Total Cash - Divgt			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PV Base (2004)		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PV Divgt		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Net Present Value	Benefit attributable to fixed link	[illegible]																				
Apollo Impacts																							
	Base																						
		Total Vehicles #	2.50%																				
		Trucks # [illegible]	15.00%																				
		Passenger Vehicles #																					
	Subsidy impact	Reference Annual Subsidy $ millions	[illegible]																				
		Sub total																					
	Net Change	Surplus(deficit)		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Capital Plan - Base																						
	Capital Plan - Divgt																						
	Total Cash - Base			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Total Cash - Divgt			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PV Base (2004)		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PV Divgt		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Net Present Value	Benefit attributable to fixed link	[illegible]																				
Transportation Net Present Value - ERR and Benefit to Cost Ratio	Fix Link Cash Flows			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Marine Atlantic Economic Benefit			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Apollo Economic Benefit			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Total Economic Cash Flow		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Present Value	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Economic Net Present Value		[illegible]																				
	Economic Rate of Return (ERR)		[illegible]																				
	Benefit /Cost Ratio		[illegible]																				
Other Economic Impacts			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Construction Impacts	Indirect plus induced GDP – NPV	[illegible]																				
	Operations Impacts	Indirect plus induced GDP – NPV	[illegible]																				
	Tourism Impacts	Total GDP Impact – NPV	[illegible]																				
	Total Spin-off Benefits	NPV	[illegible]																				
	Fixed Link Economic NPV		[illegible]																				
		Socio-economic Rate of Return	[illegible]																				
		Benefit Cost Ratio	[illegible]																				

SECTION 2 - Financial Analysis

				22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
		Project Cost, Constant 2004$		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Nominal Value		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Financing during Construction	Constr. Const. Cost	Completed at	[illegible]																				
		Interest during Construction (IDC)	[illegible]																				
		Project Costs	[illegible]																				
Financing Base Case Debt Financing	Project Cost																						
		Pre-operations cost	[illegible]																				
		Interest during Construction	[illegible]																				
	Total Amount to Finance		[illegible]																				
		Annual Debt Amortization (CRF)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Net Cash Flow		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		IRR Excl IDC	[illegible]																				
Subsidized Financing Sensitivity Case		Project Spending	[illegible]																				
		Grant Award	[illegible]																				
		Cost less Grant	[illegible]																				
	Total Amount to Finance		[illegible]																				
		Completed at																					
		Interest during Construction (IDC)	[illegible]																				

Economic Methodology for Fixed Link Project

Phase 3 - Operation

				22	23	24	25	26	27	28	29	30	31
		Project Costs	$5,230,001										
		Internal Rate of Return	8.0%	6,183,670	4,826,775	7,264,696	7,867,976	8,509,221	-21,627,418	9,914,710	10,683,846	11,520,745	-10,969,629
Section 3 - Socio-Economic Impact				22	23	24	25	26	27	28	29	30	31
Construction Effects													
	Construction Spending	Annual Civil & M&E											
		Direct GDP	34.0%										
		Indirect	63.0%										
		Induced	15.0%										
		Indirect plus induced GNP impact											
		Net Present Value	100,971,243										
Operations Impacts	Operations Costs	Annual Costs		4,966,206	6,026,206	4,966,206	4,966,206	4,966,206	20,788,206	4,966,206	4,966,206	4,966,206	28,844,206
		Direct GDP	34.0%	1,688,510	2,048,910	1,688,510	1,688,510	1,688,510	7,067,990	1,688,510	1,688,510	1,688,510	9,807,030
		Indirect	23.0%	388,357	471,249	388,357	388,357	388,357	1,625,638	388,357	388,357	388,357	2,255,617
		Induced	15.0%	311,530	378,024	311,530	311,530	311,530	1,304,044	311,530	311,530	311,530	1,809,397
		Indirect plus induced GNP impact		699,887	849,273	699,887	699,887	699,887	2,929,682	699,887	699,887	699,887	4,065,014
		Net Present Value	4,350,897	142,575	160,936	123,374	114,767	106,760	415,711	92,383	85,938	79,942	431,916
Tourism Impacts	Tourist Indicators												
		Induced Visitors – trip add on	1	73,276	75,528	77,859	80,273	82,773	85,363	88,046	90,826	93,708	96,694
		Induced Visitors – full trip	11	18,902	19,186	19,473	19,765	20,062	20,363	20,668	20,978	21,293	21,612
		Incremental Room nights	2	140,599	143,285	146,033	148,847	151,727	154,677	157,699	160,794	163,965	167,215
		Incre Annual Expenditures Tourists	62.35	17,532,751	17,867,598	18,210,323	18,561,171	18,920,394	19,288,257	19,665,034	20,051,008	20,446,477	20,851,749
		Direct GDP	35.0%	6,136,463	6,253,659	6,373,613	6,496,410	6,622,138	6,750,890	6,882,762	7,017,853	7,156,267	7,298,112
		Indirect	44.0%	2,700,044	2,751,610	2,804,390	2,858,420	2,913,741	2,970,392	3,028,415	3,087,855	3,148,757	3,211,169
		Induced	15.0%	1,325,476	1,350,790	1,376,700	1,403,225	1,430,382	1,458,192	1,486,677	1,515,856	1,545,754	1,576,392
		Total		10,161,982	10,356,059	10,554,703	10,758,055	10,966,261	11,179,474	11,397,854	11,621,564	11,850,778	12,085,673
		Net Present Value	54,374,372	2,070,104	1,962,456	1,860,557	1,764,096	1,672,779	1,586,327	1,504,479	1,426,984	1,353,608	1,284,128
TOTAL OTHER IMPACTS		Net Present Value - Real	215,695,712	2,212,679	2,123,392	1,983,931	1,878,863	1,779,539	2,002,039	1,596,862	1,512,922	1,433,550	1,716,045
Social Impacts													
	Employment	Construction & Operations											
		NL - Skilled		25	25	25	25	25	25	25	25	25	25
		NL - Unskilled		15	15	15	15	15	15	15	15	15	15
		Non-res		0	0	0	0	0	0	0	0	0	0
		Total NL Direct Employment		40	40	40	40	40	40	40	40	40	40
		Indirect Construction Employment	0.65	25	25	25	25	25	25	25	25	25	25
		Induced Construction Employment	0.3	20	20	20	20	20	20	20	20	20	20
		Total Annual FTE Employment		85	85	85	85	85	85	85	85	85	85
		Tourism											
		Total Incremental Spending		17,532,751	17,867,598	18,210,323	18,561,171	18,920,394	19,288,257	19,665,034	20,051,008	20,446,477	20,851,749
		Incremental FTE - Direct	12.8	224	229	233	238	242	247	252	257	262	267
		Incremental FTE - Indirect	0.24										
		Incremental FTE - Induced	0.15										
		Total Impact	18.3	320	326	332	338	345	352	359	366	373	381
		TOTAL RELATED EMPLOYMENT		405	411	417	423	430	437	444	451	458	466
	Wages	Construction & Operations											
		Direct Payroll		3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000
		Indirect Construction Employment	0.53	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640
		Induced Construction Employment	0.3	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492
		Sub-Total Wages		7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132
		Tourism											
		Incremental Direct Wages	23.6%	4,137,729	4,216,753	4,297,636	4,380,436	4,465,213	4,552,029	4,640,948	4,732,038	4,825,369	4,921,013
		Incremental Indirect Wages	35.0%										
		Incremental Induced Wages	15.0%										
		Sub-Total Wages	36.1%	6,328,657	6,449,524	6,573,235	6,699,877	6,829,543	6,962,328	7,098,330	7,237,652	7,380,401	7,526,689
		TOTAL RELATED WAGES		14,260,789	14,381,656	14,505,367	14,632,009	14,761,675	14,894,460	15,030,462	15,169,784	15,312,533	15,458,821
		NPV Wages	413,233,763	2,006,075	2,735,200	2,686,070	2,390,343	2,291,736	2,318,471	1,983,971	1,860,661	1,769,012	1,662,533
	Other Impacts												

				32	33	34	35	36	37	38	39	40	41
		Project Costs	$5,230,001										
		Internal Rate of Return	8.0%	13,259,298	14,267,111	15,380,878	16,466,617	9,961,786	18,816,084	20,132,358	21,378,497	23,009,713	8,447,367
Section 3 - Socio-Economic Impact				32	33	34	35	36	37	38	39	40	41
Construction Effects													
	Construction Spending	Annual Civil & M&E											
		Direct GDP	34.0%										
		Indirect	63.0%										
		Induced	15.0%										
		Indirect plus induced GNP impact											
		Net Present Value	100,971,243										
Operations Impacts	Operations Costs	Annual Costs		4,966,206	4,966,206	4,966,206	4,966,206	8,096,206	4,966,206	4,966,206	4,966,206	4,966,206	10,828,206
		Direct GDP	34.0%	1,688,510	1,688,510	1,688,510	1,688,510	2,752,710	1,688,510	1,688,510	1,688,510	1,688,510	3,681,590
		Indirect	23.0%	388,357	388,357	388,357	388,357	633,123	388,357	388,357	388,357	388,357	846,766
		Induced	15.0%	311,530	311,530	311,530	311,530	507,875	311,530	311,530	311,530	311,530	679,253
		Indirect plus induced GNP impact		699,887	699,887	699,887	699,887	1,140,998	699,887	699,887	699,887	699,887	1,526,019
		Net Present Value	4,350,897	69,178	64,350	59,861	55,684	84,440	48,185	44,824	41,696	38,787	78,671
Tourism Impacts	Tourist Indicators												
		Induced Visitors – trip add on	1	99,790	103,001	106,330	109,784	113,366	117,083	120,941	124,945	129,101	133,416
		Induced Visitors – full trip	11	21,937	22,266	22,600	22,939	23,283	23,632	23,986	24,346	24,711	25,082
		Incremental Room nights	2	170,548	173,961	177,461	181,054	184,738	188,517	192,396	196,376	200,463	204,659
		Incre Annual Expenditures Tourists	62.35	21,267,143	21,692,994	22,129,648	22,577,467	23,036,827	23,508,119	23,991,751	24,488,147	24,997,751	25,521,022
		Direct GDP	35.0%	7,443,500	7,592,548	7,745,377	7,902,114	8,062,889	8,227,842	8,397,113	8,570,852	8,749,213	8,932,358
		Indirect	44.0%	3,275,140	3,340,721	3,407,966	3,476,930	3,547,671	3,620,250	3,694,730	3,771,175	3,849,654	3,930,237
		Induced	15.0%	1,607,796	1,639,990	1,673,001	1,706,857	1,741,584	1,777,214	1,813,776	1,851,304	1,889,830	1,929,389
		Total		12,326,436	12,573,259	12,826,344	13,085,901	13,352,144	13,625,306	13,905,619	14,193,330	14,488,696	14,791,984
		Net Present Value	54,374,372	1,218,335	1,156,029	1,097,021	1,041,136	988,203	938,065	890,571	845,578	802,954	762,569
TOTAL OTHER IMPACTS		Net Present Value - Real	215,695,712	1,287,513	1,220,379	1,156,882	1,096,820	1,072,650	986,251	935,395	887,275	841,741	841,240
Social Impacts													
	Employment	Construction & Operations											
		NL - Skilled		25	25	25	25	25	25	25	25	25	25
		NL - Unskilled		15	15	15	15	15	15	15	15	15	15
		Non-res		0	0	0	0	0	0	0	0	0	0
		Total NL Direct Employment		40	40	40	40	40	40	40	40	40	40
		Indirect Construction Employment	0.65	25	25	25	25	25	25	25	25	25	25
		Induced Construction Employment	0.3	20	20	20	20	20	20	20	20	20	20
		Total Annual FTE Employment		85	85	85	85	85	85	85	85	85	85
		Tourism											
		Total Incremental Spending		21,267,143	21,692,994	22,129,648	22,577,467	23,036,827	23,508,119	23,991,751	24,488,147	24,997,751	25,521,022
		Incremental FTE - Direct	12.8	272	278	283	289	295	301	307	313	320	327
		Incremental FTE - Indirect	0.24										
		Incremental FTE - Induced	0.15										
		Total Impact	18.3	388	396	404	412	420	429	438	447	456	466
		TOTAL RELATED EMPLOYMENT		473	481	489	497	505	514	523	532	541	551
	Wages	Construction & Operations											
		Direct Payroll		3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000
		Indirect Construction Employment	0.53	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640
		Induced Construction Employment	0.3	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492
		Sub-Total Wages		7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132
		Tourism											
		Incremental Direct Wages	23.6%	5,019,046	5,119,547	5,222,597	5,328,282	5,436,691	5,547,916	5,662,053	5,779,203	5,899,469	6,022,961
		Incremental Indirect Wages	35.0%										
		Incremental Induced Wages	15.0%										
		Sub-Total Wages	36.1%	7,676,630	7,830,346	7,987,962	8,149,608	8,315,419	8,485,538	8,660,150	8,839,291	9,023,238	9,212,119
		TOTAL RELATED WAGES		15,608,762	15,762,478	15,920,094	16,081,740	16,247,551	16,417,670	16,592,282	16,771,423	16,955,370	17,144,251
		NPV Wages	413,233,763	1,565,757	1,469,250	1,381,021	1,279,490	1,202,495	1,130,312	1,083,633	990,171	939,656	883,850
	Other Impacts												

ECONOMIC ANALYSIS WORKSHEETS – BASE CASE WITH HVDC INCOME

Economic Methodology for Fixed Link Project

Section 1 - Transportation Economics

				Phase 1 - Planning Approval			Phase 2 - Design & Construction																	
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Traffic	Travellers																							
	(one way trips)	Tourist Visitors - ferry/link	3.50%	13,000	13,455	13,926	14,413	14,918	15,440	15,980	16,540	17,119	17,718	18,338	18,980	19,644	20,331	21,043	21,780	22,542	23,331	24,147	24,993	25,867
		Traditional Tourist Vehicles		4,869	5,039	5,216	5,398	5,587	5,783	5,985	6,195	6,411	6,636	6,868	7,108	7,357	7,615	7,881	8,157	8,443	8,738	9,044	9,360	9,688
		Induced Visitors - fixed Link	1.25%												228	477	746	1,035	1,347	1,684	2,045	2,434	2,852	3,299
		Induced Demand Vehicles - Tourists	2.67												86	179	279	388	505	631	766	912	1,068	1,236
		Tourist Vehicles - ferry/link	2.67	4,869	5,039	5,216	5,398	5,567	5,783	5,985	6,195	6,411	6,636	6,868	7,194	7,536	7,894	8,269	8,662	9,073	9,504	9,956	10,429	10,924
	Passenger Veh																							
	Labrador	Local and Business Traffic Base	1.5%	16,769	17,139	17,518	17,901	18,297	18,698	19,108	19,526	19,952	20,387	20,830	27,079	27,485	27,898	28,316	28,741	29,172	29,610	30,054	30,505	30,962
		one-time surge	30.0%																					
	Cabot	Diverted Passenger Vehicles													20,334	20,842	21,363	21,897	22,445	23,006	23,581	24,170	24,775	25,394
		Induced Demand Veh %	1.50%												6,100	6,192	6,284	6,379	6,474	6,572	6,670	6,770	6,872	6,975
		One time effect	30.0%																					
	Total	Total Passenger Vehicles													60,793	62,234	63,718	65,249	66,828	68,453	70,131	71,861	73,647	75,490
		Total Induced Vehicle Trips		0	0	0	0	0	0	0	0	0	0	0	6,186	6,370	6,564	6,766	6,979	7,203	7,436	7,682	7,940	8,211
		Total Visitors	2.67												162,318	166,164	170,129	174,214	178,420	182,769	187,249	191,870	196,638	201,559
	Base Freight																							
		Cabot/Oceanex Tractor-trailer	2.50%	142,402	145,962	149,611	153,351	157,185	161,115	165,143	169,271	173,503	177,841	182,287	186,844	191,515	196,303	201,210	206,241	211,397	216,681	222,099	227,651	233,342
		Apollo Tractor-trailer		2,404	2,464	2,526	2,589	2,654	2,720	2,788	2,858	2,929	3,003	3,078	3,155	3,233	3,314	3,397	3,482	3,569	3,658	3,750	3,843	3,940
		Diverted Cabot/Oceanex Tractor-Trailer	10%												18,684	19,151	19,630	20,121	20,624	21,140	21,668	22,210	22,765	23,334
		Induced Cabot/Oceanex Tractor-Trailer	1.0%												1,868	1,915	1,963	2,012	2,062	2,114	2,167	2,221	2,277	2,333
		Total Tractor-trailer													23,707	24,300	24,908	25,530	26,168	26,823	27,493	28,181	28,885	29,607
	Design Peak Hour Vol	Autos													38	39	40	41	42	43	44	45	46	47
		Trucks													8	9	9	9	9	9	10	10	10	10
		PCUs	2.5												59	60	62	63	65	67	68	70	72	74
		Dominant Direction (ratio)	50.00%												29	30	31	32	32	33	34	35	36	37
Revenues Total															30,995,956	31,159,527	31,327,561	31,500,196	31,677,575	31,859,847	32,047,166	32,239,691	32,437,587	32,641,024
	Passenger Tolls														1,015,245	1,039,305	1,064,098	1,089,653	1,115,998	1,143,164	1,171,183	1,200,087	1,229,911	1,260,690
	Vehicle Tolls														1,854,190	1,898,132	1,943,413	1,990,085	2,038,200	2,087,815	2,138,986	2,191,775	2,246,244	2,302,458
	Freight Tolls														3,822,808	3,918,378	4,016,337	4,116,746	4,219,664	4,325,156	4,433,285	4,544,117	4,657,720	4,774,163
	Transmission Fee														17,198,000	17,198,000	17,198,000	17,198,000	17,198,000	17,198,000	17,198,000	17,198,000	17,198,000	17,198,000
	Cable recovery														7,105,712	7,105,712	7,105,712	7,105,712	7,105,712	7,105,712	7,105,712	7,105,712	7,105,712	7,105,712
	Other																							
Expenses Total															4,555,581	4,555,581	4,555,581	4,555,581	4,555,581	4,555,581	4,775,581	4,555,581	4,555,581	4,966,206
	Operations																							
		Wages													3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000
		Energy													481,581	481,581	481,581	481,581	481,581	481,581	481,581	481,581	481,581	892,206
	Annual Maintenance																							
		Wages													614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000
		Purchased Serv & Supp													86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000
	Periodic Maintenance																							
		Purchased Serv & Supp																			220,000			
Gross Operating (Surplus/Deficit)															26,440,375	26,603,946	26,771,980	26,944,615	27,121,994	27,304,266	27,271,585	27,684,110	27,882,006	27,674,818
Total Capital Investment (Outflow)	Pre-operation		1,261,466,303	11,000,000	2,000,000	2,000,000	24,975,000	24,975,000	143,684,64[illegible]	[illegible]9,022	254,041,183	182,458,739	227,057,044	172,485,669										
	Operations Phase		0												0	0	0	0	0	0	0	0	0	0
	Infrastructure																							
		Civil Works	971,740,540	11,000,000	2,000,000	2,000,000	24,975,000	24,975,000	121,888,283	194[illegible]618	232,244,820	160,662,375	110,483,853	60,518,532										
		M & E	17,004,000		0	0	0	0	0	0	0	0	10,627,500	6,376,500										
		Systems	29,672,471		0	0	0	0	0	0	0	0	19,781,648	9,890,824										
		Rolling Stock	37,367,772	0	0	0	0	0	0	0	0	0	0	37,367,772										
		Cable	77,000,000	0	0	0	0	0	0	0	0	0	38,500,000	38,500,000										
	Sub total		1,132,784,783																					
	Other (Design, Proj. Mgt)		128,681,520	0	0	0	0	0	21,796,364	21,796,364	21,796,364	21,796,364	27,664,044	13,832,022										
TOTAL CAPEX		$ 2004	1,261,466,303																					
Present Values at Social Discount Rate	Present Value Income Operation Phase		175,508,861												13,013,760	12,169,727	11,381,725	10,645,996	9,959,018	9,317,509	8,718,410	8,158,871	7,636,234	7,148,074
	Present Value Cost Operation Phase		-30,867,079												1,912,679	1,779,227	1,655,104	1,539,622	1,432,215	1,332,293	1,299,194	1,152,877	1,072,444	1,087,544
	Present Value Capital Investment		-699,069,609	-10,232,558	-1,732,665	-1,609,921	-18,701,293	-17,296,552	-93,102,122	-130,670,645	-142,441,459	-95,167,463	-110,166,699	-77,850,232										
	Net Present Value of Fixed Link Cash Flows		-554,427,827																					
Benefit Cost Ratio and IRR	Fixed Link Cash Flows	cash undiscounted	-432,951,286	-11,000,000	-2,000,000	-2,000,000	-24,975,000	-24,975,000	-143,684,647	-216,789,022	-254,041,183	-182,458,739	-227,057,044	-172,485,669	26,440,375	26,603,946	26,771,980	26,944,615	27,121,994	27,304,266	27,271,585	27,684,110	27,882,006	27,674,818
	Real Internal Rate of Return (RIRR)		-3.1%																					
	Benefit /Cost Ratio		0.24																					
Indirect Transportation																								
Marine Atlantic Impacts																								
	Passenger Vehicles																							
		Base Projection # Vehicle trips	2.50%	154972	158,846	162,817	166,888	171,060	175,337	179,720	184,213	188,818	193,539	198,377	203,337	208,420	213,631	218,971	224,446	230,057	235,808	241,703	247,746	253,940
		Vehicle trips diverted	10%												-20,334	-20,842	-21,363	-21,897	-22,445	-23,006	-23,581	-24,170	-24,775	-25,394
		Net Vehicle trips													183,003	187,578	192,268	197,074	202,001	207,051	212,227	217,533	222,971	228,546
		Passenger Vehicle Revenue $	148	22,935,856	23,509,252	24,096,984	24,699,408	25,316,894	25,949,816	26,598,561	27,263,525	27,945,113	28,643,741	29,359,835	27,084,448	27,761,559	28,455,598	29,166,988	29,896,162	30,643,566	31,409,656	32,194,897	32,999,769	33,824,764
	Freight tractor-trailer																							
		Base Projection Tractor trailer	3/3	94,935	97,308	99,741	102,234	104,790	107,410	110,095	112,847	115,669	118,560	121,524	124,563	127,677	130,869	134,140	137,494	140,931	144,454	148,066	151,767	155,562
		Diverted Freight tractor trailer	1												-18,684	-19,151	-19,630	-20,121	-20,624	-21,140	-21,668	-22,210	-22,765	-23,334
		Net Freight tractor trailer													105,878	108,525	111,238	114,019	116,870	119,791	122,786	125,856	129,002	132,227
		Net Revenue $	257.35	24,431,943	25,032,492	25,638,304	26,299,761	26,957,235	27,631,167	28,321,967	29,030,016	29,755,766	30,499,600	31,262,152	27,237,150	27,918,078	28,616,030	29,331,431	30,064,717	30,816,335	31,586,743	32,376,412	33,185,822	34,015,468
		Change in Pass. Car Equivalent Veh. (PCU)			2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.6%	2.6%	-11.1%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
	Total Operating Cost		111	111,100,000	112,319,750	113,554,324	114,803,907	116,068,686	117,348,848	118,644,585	119,956,092	121,283,563	122,660,789	124,090,308	117,989,626	119,293,109	120,612,457	121,947,867	123,299,540	124,667,677	126,052,482	127,454,164	128,872,932	130,308,999

Economic Methodology for Fixed Link Project				Phase 1 - Planning Approval			Phase 2 - Design & Construction																	
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
		Wages	64.3	64,300,000	65,103,750	65,917,547	66,741,516	67,575,785	68,420,482	69,275,739	70,141,685	71,018,456	71,928,380	72,873,002	68,839,845	69,700,341	70,571,593	71,453,740	72,346,012	73,251,248	74,166,889	75,093,975	76,032,649	76,983,058
		Fuel	16.9	16,900,000	16,942,250	16,984,606	17,027,067	17,069,635	17,112,309	17,155,090	17,197,977	17,240,972	17,283,152	17,330,553	17,138,721	17,181,568	17,224,522	17,267,584	17,310,753	17,354,029	17,397,414	17,440,907	17,484,510	17,528,221
		Purchased Goods & Ser	29.9	29,900,000	30,273,750	30,652,172	31,035,324	31,423,266	31,816,056	32,213,757	32,616,429	33,024,134	33,447,256	33,886,513	32,011,062	32,411,200	32,816,340	33,226,545	33,641,876	34,062,400	34,488,180	34,919,282	35,355,773	35,797,720
	Subsidy impact	- reference subsidy $mm	43.8																					
		Incremental gain (loss)													1,715,497	8,581,767	8,791,018	8,003,063	8,827,316	8,843,013	8,564,093	9,198,695	9,132,963	9,761,037
	Net Revenue	Operating Surplus(deficit)		-63,742,201	-63,778,006	-63,799,037	-63,804,730	-63,794,517	-63,767,845	-63,724,057	-63,662,551	-63,582,684	-63,517,387	-63,468,081	-61,663,078	-62,309,988	-63,340,829	-63,449,448	-63,338,081	-63,207,775	-63,050,081	-62,881,811	-62,687,241	-62,468,767
	Capital Plan - Base	$ Millions					75			100					150		150		150					
	Capital Plan - Divert	$ Millions					75			100													100	
	Total Cash - Base			-63,742,201	-63,778,006	-63,799,037	-138,804,730	-63,794,517	-63,767,845	-163,724,057	-63,662,551	-63,582,684	-63,517,387	-63,468,081	-211,912,332	-53,728,221	-204,190,811	-54,449,089	-204,711,578	-54,964,758	-53,991,990	-53,592,160	-53,104,378	-52,707,731
	Total Cash - Divert			-63,742,201	-63,778,006	-63,799,037	-138,804,730	-63,794,517	-63,767,845	-163,724,057	-63,662,551	-63,582,684	-63,517,387	-63,468,081	-61,663,078	-62,309,988	-63,340,829	-63,449,448	-63,338,081	-63,207,775	-63,050,081	-62,881,811	-162,687,241	-62,468,767
	PV Base (2004)		-1,264,206,082	-59,295,071	-55,189,189	-51,355,709	-103,937,061	-44,436,635	-41,319,110	-98,685,470	-35,695,734	-33,163,677	-30,818,231	-28,645,886	-88,989,146	-20,583,419	-74,288,364	-18,100,927	-64,359,579	-13,899,137	-14,888,484	-13,567,277	-12,313,594	-11,545,412
	PV Divert		-1,255,298,330	-59,295,071	-55,189,189	-51,355,709	-103,937,061	-44,436,635	-41,319,110	-98,685,470	-35,695,734	-33,163,677	-30,818,231	-28,645,886	-26,731,285	-24,315,912	-23,093,279	-21,441,718	-39,912,871	-18,483,203	-17,151,365	-15,913,710	-85,281,309	-13,679,971
	Net Present Value	Benefit attributable to fixed link	26,007,753																					
Apollo Impacts																								
	Base																							
		Total Vehicles #	2.50%	24042	24643	25259	25891	26538	27201	27881	28578	29293	30025	30776										
		Trucks # (x0.1)	10.00%	2,404	2,464	2,526	2,589	2,654	2,720	2,788	2,858	2,929	3,003	3,078										
		Passenger Vehicles #		21,638	22,179	22,733	23,302	23,884	24,481	25,093	25,721	26,364	27,023	27,698										
	Subsidy impact	Reference Annual Subsidy $ millions	5.5																					
		Lift total																						
	Net Change	Surplus(deficit)		-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0
	Capital Plan - Base												75											
	Capital Plan - Divert												20											
	Total Cash - Base			-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-80,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000
	Total Cash - Divert			-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-25,500,000	-5,500,000	0	0	0	0	0	0	0	0	0	0
	PV Base (2004)		-110,098,784	-5,116,279	-4,759,329	-4,427,283	-4,118,403	-3,831,072	-3,563,788	-3,315,152	-3,083,862	-2,868,709	-39,058,111	-2,482,388	-2,309,198	-2,148,091	-1,998,224	-1,858,813	-1,729,128	-1,608,492	-1,496,271	-1,391,880	-1,294,772	-1,204,439
	PV Divert		-49,938,711	-5,116,279	-4,759,329	-4,427,283	-4,118,403	-3,831,072	-3,563,788	-3,315,152	-3,083,862	-2,868,709	-12,372,445	-2,482,388	0	0	0	0	0	0	0	0	0	0
	Net Present Value	Benefit attributable to fixed link	60,160,073																					
Transportation Net Present Value - ERR and Benefit to Cost Ratio	Fix Link Cash Flow			-11,000,000	-2,000,000	-2,000,000	-24,975,000	-24,975,000	-143,684,647	-216,789,022	-254,041,183	-182,458,739	-227,057,044	-172,485,669	26,440,375	26,603,946	26,771,980	26,944,615	27,121,994	27,304,266	27,271,585	27,684,110	27,882,006	27,674,818
	Marine Atlantic Economic Benefit			0	0	0	0	0	0	0	0	0	0	0	148,281,383	8,583,767	141,208,993	9,003,063	141,372,006	8,843,017	9,064,093	9,288,093	189,533,563	9,761,037
	Apollo Economic Benefit			0	0	0	0	0	0	0	0	0	55,000,000	0	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000
	Total Economic Cash Flow		-226,729,966	-11,000,000	-2,000,000	-2,000,000	-24,975,000	-24,975,000	-143,684,647	-216,789,022	-254,041,183	-182,458,739	-172,057,044	-172,485,669	180,224,878	32,529,179	173,480,981	33,441,752	173,994,000	33,961,249	33,787,193	33,891,413	226,140,957	32,413,781
		Present Value	-465,660,082	-10,232,550	-1,730,665	-1,609,921	-18,701,293	-17,396,552	-93,102,122	-130,670,645	-142,441,459	-95,167,463	-83,481,033	-77,850,232	75,668,159	8,184,088	68,037,930	7,912,147	54,701,658	7,007,180	6,489,687	6,346,688	41,807,212	5,123,360
	Economic Net Present Value		-465,660,082																					
	Economic Rate of Return (ERR)		-1.1%																					
	Benefit /Cost Ratio		0.38																					
Other Economic Impacts			432,712,179	-3,729,370	1,405,340	1,405,340	-17,549,183	-17,549,183	-167,447,603	-158,811,855	-184,987,831	-134,688,995	-130,100,405	-150,811,783	189,311,641	32,762,078	182,881,461	33,005,743	183,727,864	33,858,763	33,890,701	34,141,214	245,711,952	33,086,884
	Construction Impacts	Indirect plus Induced GDP – NPV	166,971,243																					
	Operations Impacts	Indirect plus Induced GDP – NPV	6,350,097																					
	Tourism Impacts	Total GDP Impact – NPV	54,374,372																					
	Total Spin-off Benefits	NPV	215,695,712																					
	Fixed Link Economic NPV		-239,964,289																					
		Socio-economic Rate of Return	3.3%																					
		Benefit/Cost Ratio	0.70																					

SECTION 2 - Financial Analysis

				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
		Project Cost, Constant 2004$		-11,000,000	-2,000,000	-2,000,000	-24,975,000	-24,975,000	-143,684,647	-216,789,022	-254,041,183	-182,458,739	-227,057,044	-172,485,669	26,440,375	26,603,946	26,771,980	26,944,615	27,121,994	27,304,266	27,271,585	27,684,110	27,882,006	27,674,818
		Nominal Value		-11,275,000	-2,101,250	-2,153,781	-27,261,727	-28,256,920	-100,630,139	-257,094,022	-309,524,514	-227,865,961	-290,652,213	-226,316,145	35,519,368	36,673,833	37,828,106	39,023,836	40,262,751	41,548,670	42,514,180	44,237,208	45,687,913	46,487,122
Financing during Construction	Comm. Const. Cost	Comprised of:	-1,812,607,275	-11,275,000	-13,650,125	-16,442,281	-44,178,230	74,384,919	-244,237,880	-500,979,042	-810,559,108	-1,108,614,917	-1,440,601,222	-1,731,581,122										
		Interest during Construction (IDC)	-262,569,603	-281,875	-630,375	-768,278	-1,349,721	3,022,833	8,046,141	-19,096,352	-34,189,845	-49,314,097	-64,703,750	-80,926,152										
		Project Costs	-1,550,037,672																					
Financing Base Case	Project Cost																							
Debt Financing		Pre operations cost	1,550,037,672																					
		Interest during Construction	262,569,603																					
	Total Amount to Finance		1,812,607,275																					
		Annual Debt Amortization (CRF)	-200,344,730												-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730
		Net Cash Flow													-164,785,363	-163,670,897	-162,516,623	-161,320,894	-160,081,977	-158,798,059	-157,810,564	-156,097,522	-154,656,817	-111,862,608
		Internal Rate of Return	5.4%																					
Subsidized Financing Sensitivity Case		Project Spending	1,550,037,672	11,275,000	2,101,250	2,153,781	27,261,727	28,256,920	100,630,139	257,094,022	309,524,514	227,865,962	290,652,212	226,316,145										
		Grant Award	1,050,000,000	11,275,000	2,101,250	2,153,781	27,261,727	28,256,920	100,630,139	257,094,022	309,524,514	227,865,961	16,930,685	0										
		Cost less Grant	500,037,672	0	0	0	0	0	0	0	0	0	273,721,527	226,316,145										
	Total Amount to Finance		526,566,842																					
		Comprised of:		0	0	0	0	0	0	0	0	0	273,721,527	306,890,710										
		Interest during Construction (IDC)	26,529,170	0	0	0	0.00	0	0	0	0	0	6,841,028	19,688,122										
		Project Costs	906,537,672																					

Economic Methodology for Fixed Link Project

				Phase 1 - Planning Approval			Phase 2 - Design & Construction																	
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
		Internal Rate of Return	7.6%	0	0	0	0	0	0	0	0	0	280,564,565	-246,002,277	35,559,365	36,673,833	37,828,106	39,023,836	40,262,755	41,546,670	42,534,366	44,257,208	45,687,913	46,482,122
	Section 3 - Socio-Economic Impact			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Construction Effects																								
	Construction Spending	Annual Civil & M&E		11,000,000	2,000,000	2,000,000	24,975,000	24,975,000	121,888,283	194,997,658	232,244,820	160,662,375	141,111,352	72,895,052										
		Direct GDP	34.0%	3,740,000	680,000	680,000	8,491,500	8,491,500	41,442,016	66,297,504	78,963,239	54,625,207	47,977,860	24,784,318										
		Indirect	63.0%	2,356,200	428,400	428,400	5,349,645	5,349,645	26,108,470	41,767,427	49,746,840	34,413,881	30,226,052	15,614,120										
		Induced	15.0%	914,430	166,260	166,260	2,076,172	2,076,172	10,132,573	16,209,740	19,306,512	13,355,663	11,730,587	6,059,766										
		Indirect plus induced GNP impact		3,270,630	594,660	594,660	7,425,817	7,425,817	36,241,043	57,977,167	69,053,352	47,769,744	41,956,638	21,673,886										
		Net Present Value	166,971,243	3,042,447	514,579	478,678	5,560,456	5,172,517	23,482,801	34,946,022	38,718,369	24,915,909	20,357,106	9,782,361										
Operations Impacts	Operations Costs	Annual Costs													4,555,581	4,555,581	4,555,581	4,555,581	4,555,581	4,555,581	4,775,581	4,555,581	4,555,581	4,966,206
		Direct GDP	34.0%												1,548,898	1,548,898	1,548,898	1,548,898	1,548,898	1,548,898	1,623,698	1,548,898	1,548,898	1,688,510
		Indirect	23.0%												356,246	356,246	356,246	356,246	356,246	356,246	373,450	356,246	356,246	388,357
		Induced	15.0%												285,772	285,772	285,772	285,772	285,772	285,772	299,572	285,772	285,772	311,530
		Indirect plus induced GNP impact													642,018	642,018	642,018	642,018	642,018	642,018	673,023	642,018	642,018	699,887
		Net Present Value	4,350,097												260,554	250,748	233,254	216,982	201,842	187,760	183,093	162,475	151,139	153,268
Tourism Impacts	Tourist Indicators																							
		Induced Visitors – trip add-on	1												54,520	56,126	57,783	59,500	61,274	63,109	65,006	66,969	69,000	71,101
		Induced Visitors – full trip	11												16,287	16,532	16,780	17,031	17,287	17,546	17,809	18,076	18,347	18,623
		Incremental Room nights	2	6,500	6,728	6,963	7,207	7,459	7,720	7,990	8,270	8,559	8,859	9,169	116,840	118,986	121,180	123,422	125,714	128,057	130,454	132,904	135,411	137,976
		Incre Annual Expenditures Tourists	62.35												14,569,953	14,837,609	15,111,147	15,390,735	15,678,547	15,968,765	16,267,575	16,573,173	16,885,760	17,205,547
		Direct GDP	35.0%												5,099,484	5,193,163	5,288,902	5,386,757	5,486,792	5,589,068	5,693,651	5,800,610	5,910,016	6,021,941
		Indirect	44.0%												2,243,773	2,284,992	2,327,117	2,370,173	2,414,188	2,459,190	2,505,207	2,552,269	2,600,407	2,649,654
		Induced	15.0%												1,101,488	1,121,723	1,142,403	1,163,540	1,185,147	1,207,239	1,229,829	1,252,932	1,276,563	1,300,739
		Total													8,444,745	8,599,878	8,758,421	8,920,470	9,086,127	9,255,498	9,428,686	9,605,811	9,786,987	9,972,335
		Net Present Value	54,374,372												3,545,561	3,358,786	3,182,052	3,014,816	2,856,560	2,706,796	2,563,068	2,430,934	2,303,985	2,183,831
TOTAL OTHER IMPACTS		Net Present Value - Real	225,695,712	3,042,447	514,579	478,678	5,560,456	5,172,517	23,482,801	34,946,022	38,718,369	24,915,909	20,357,106	9,782,361	3,815,415	3,609,533	3,415,306	3,231,798	3,058,402	2,894,558	2,748,163	2,593,409	2,455,125	2,337,099
Social Impacts																								
	Employment	Construction & Operations																						
		NL - Skilled		0	0	0	0	0	192	229	257	201	247	182	25	25	25	25	25	25	25	25	25	25
		NL - Unskilled		0	0	0	0	0	166	233	278	184	202	102	15	15	15	15	15	15	15	15	15	15
		Non-res		0	0	0	0	0	0	19	29	24	4	2	0	0	0	0	0	0	0	0	0	0
		Total NL Direct Employment		0	0	0	0	0	358	462	535	385	449	284	40	40	40	40	40	40	40	40	40	40
		Indirect Construction Employment	0.63	0	0	0	0	0	226	291	337	243	283	179	25	25	25	25	25	25	25	25	25	25
		Induced Construction Employment	0.3	0	0	0	0	0	175	220	262	188	220	139	20	20	20	20	20	20	20	20	20	20
		Total Annual FTE Employment		0	0	0	0	0	759	979	1,134	816	951	602	85	85	85	85	85	85	85	85	85	85
		Tourism																						
		Total Incremental Spending													14,569,953	14,837,609	15,111,147	15,390,735	15,676,547	15,968,765	16,267,575	16,573,173	16,885,760	17,205,547
		Incremental FTE - Direct	12.8												186	190	193	197	201	204	208	212	216	220
		Incremental FTE - Indirect	0.24																					
		Incremental FTE - Induced	0.15																					
		Total Impact	18.3												266	271	276	281	286	291	297	303	308	314
		TOTAL RELATED EMPLOYMENT			0	0	0	0	759	979	1,134	816	951	602	351	356	361	366	371	376	382	387	393	399
	Wages	Construction & Operations																						
		Direct Payroll		3,300,000	600,000	600,000	7,492,500	7,492,500	38,566,485	58,497,797	69,673,446	48,198,712	42,333,406	21,868,515	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000
		Indirect Construction Employment	0.53	1,749,000	318,000	318,000	3,971,025	3,971,025	19,380,237	31,003,833	36,926,926	25,545,318	22,436,705	11,590,313	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640
		Induced Construction Employment	0.3	1,514,700	275,400	275,400	3,439,058	3,439,058	16,784,017	26,850,489	31,980,112	22,123,209	19,431,033	10,037,649	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492
		Sub-Total Wages		6,563,700	1,193,400	1,193,400	14,902,583	14,902,583	72,730,738	116,352,119	138,580,484	95,867,239	84,201,144	43,496,477	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132
		Tourism																						
		Incremental Direct Wages	23.6%												3,418,500	3,501,676	3,586,221	3,632,214	3,699,665	3,768,628	3,839,148	3,911,209	3,985,039	4,060,509
		Incremental Indirect Wages	33.0%																					
		IncrementalInduced Wages	15.0%																					
		Sub-Total Wages	36.1%												5,250,199	5,355,813	5,454,330	5,555,471	5,658,638	5,764,117	5,871,976	5,982,286	6,095,118	6,210,549
		TOTAL RELATED WAGES		6,563,700	1,193,400	1,193,400	14,902,583	14,902,583	72,730,738	116,352,119	138,580,484	95,867,239	84,201,144	43,496,477	13,182,331	13,287,945	13,386,462	13,487,603	13,590,770	13,696,249	13,804,108	13,914,418	14,027,250	14,142,681
		NPV Wages	411,233,763	6,105,767	1,032,688	960,640	11,159,062	10,380,522	47,126,720	70,131,810	77,702,387	50,002,768	40,853,884	19,631,839	5,538,435	5,189,766	4,863,562	4,558,351	4,273,781	4,005,509	3,755,398	3,521,310	3,302,195	3,097,691
	Other Impacts																							

Economic Methodology for Fixed Link Project

Section 1 - Transportation Economics

				Phase 3 - Operation									
				22	23	24	25	26	27	28	29	30	31
Traffic	Travellers (one-way trips)	Tourist Visitors - ferry/link	3.50%	26,773	27,710	28,679	29,683	30,722	31,797	32,910	34,062	35,254	36,488
		Traditional Tourist Vehicles		10,027	10,378	10,741	11,117	11,506	11,909	12,326	12,757	13,204	13,666
		Induced Visitors - fixed Link	1.25%	3,780	4,294	4,844	5,433	6,062	6,734	7,451	8,216	9,032	9,902
		Induced Demand Vehicles - Tourists	2.67	1,416	1,608	1,814	2,035	2,270	2,522	2,791	3,077	3,383	3,709
		Tourist Vehicles - ferry/link	2.67	11,443	11,986	12,556	13,152	13,777	14,431	15,117	15,835	16,587	17,375
	Passenger Veh												
	Labrador	Local and Business Traffic Base	1.5%	31,427	31,898	32,376	32,862	33,355	33,855	34,363	34,879	35,402	35,933
		one-time surge	30.0%										
	Cabot	Diverted Passenger Vehicles		26,029	26,680	27,347	28,030	28,731	29,449	30,185	30,940	31,714	32,506
		Induced Demand Veh %	1.50%	7,079	7,186	7,293	7,403	7,514	7,627	7,741	7,857	7,975	8,095
		One time effect	30.0%										
	Total	Total Passenger Vehicles		77,393	79,357	81,386	83,482	85,647	87,884	90,197	92,588	95,060	97,617
		Total Induced Vehicle Trips		8,495	8,794	9,108	9,437	9,784	10,149	10,532	10,934	11,358	11,803
		Total Visitors	2.67	206,639	211,884	217,301	222,896	228,677	234,651	240,825	247,209	253,810	260,637
	Base Freight												
		Cabot/Oceanex Tractor trailer	2.50%	239,176	245,155	251,284	257,566	264,005	270,605	277,371	284,305	291,413	298,698
		Apollo Tractor-trailer		4,038	4,139	4,242	4,349	4,457	4,569	4,683	4,800	4,920	5,043
		Diverted Cabot/Oceanex Tractor-Trailer	10%	23,918	24,516	25,128	25,757	26,401	27,061	27,737	28,430	29,141	29,870
		Induced Cabot/Oceanex Tractor-Trailer	1.0%	2,392	2,452	2,513	2,576	2,640	2,706	2,774	2,843	2,914	2,987
		Total Tractor trailer		30,347	31,106	31,884	32,681	33,498	34,335	35,194	36,074	36,975	37,900
	Design Peak Hour Vol	Autos		48	50	51	52	54	55	56	58	59	61
		Trucks		11	11	11	12	12	12	12	13	13	13
		PCUs	2.5	75	77	79	81	83	85	88	90	92	95
		Dominant Direction (ratio)	50.00%	38	39	40	41	42	43	44	45	46	47
Revenue Total				32,850,180	33,065,238	33,286,389	33,513,830	33,747,766	33,988,608	34,235,976	34,490,700	34,752,815	35,022,566
	Passenger Tolls			1,297,461	1,325,269	1,359,149	1,394,144	1,430,301	1,467,665	1,506,285	1,546,212	1,587,500	1,630,204
	Vehicle Tolls			2,360,487	2,420,402	2,482,277	2,546,191	2,612,226	2,680,465	2,751,000	2,823,921	2,899,327	2,977,318
	Freight Tolls			4,893,517	5,015,855	5,141,251	5,269,783	5,401,527	5,536,565	5,674,982	5,816,856	5,962,277	6,111,332
	Transmission Fee			17,198,000	17,198,000	17,198,000	17,198,000	17,198,000	17,198,000	17,198,000	17,198,000	17,198,000	17,198,000
	Cable recovery			7,105,712	7,105,712	7,105,712	7,105,712	7,105,712	7,105,712	7,105,712	7,105,712	7,105,712	7,105,712
	Other												
Expenses Total				4,966,206	6,026,206	4,966,206	4,966,206	4,966,206	20,788,206	4,966,206	4,966,206	4,966,206	20,844,206
	Operations												
		Wages		3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000
		Energy		892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206
	Annual Maintenance												
		Wages		614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000
		Purchased Serv & Supp		86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000
	Periodic Maintenance												
		Purchased Serv & Supp			1,060,000				15,822,000				15,878,000
Gross Operating (Surplus/Deficit)				27,883,974	27,039,032	28,320,183	28,547,624	28,781,560	13,200,402	29,269,770	29,524,494	29,786,609	6,178,360
Total Capital Investments (Outflow)	Pre-operation		1,261,466,303										
	Operations Phase		0	0	0	0	0	0	0	0	0	0	0
	Infrastructure												
		Civil Works	971,740,348										
		M & E	13,304,000										
		Systems	29,612,411										
		Rolling Stock	31,867,772										
		Cable	71,300,200										
	Sub total		1,115,784,783										
	Other (Design, Proj. Mgt)		178,681,519										
TOTAL CAPEX		$ 2004	1,261,466,303										
Present Values at Social Discount Rate	Present Value Income Operation Phase		175,508,861	6,691,932	6,363,887	5,867,641	5,495,566	5,147,839	4,822,834	4,519,035	4,235,020	3,969,502	3,721,222
	Present Value Cost Operation Phase		-30,867,079	1,011,909	1,141,956	875,430	814,354	757,538	2,949,772	655,523	609,789	567,245	3,064,738
	Present Value Capital Investment		-699,069,609										
	Net Present Value of Fixed Link Cash Flows		-554,427,827										
Benefit Cost Ratio and IRR	Fixed Link Cash Flows	sum undiscounted	-432,951,286	27,883,974	27,039,032	28,320,183	28,547,624	28,781,560	13,200,402	29,269,770	29,524,494	29,786,609	6,178,360
	Real Internal Rate of Return (RIRR)		-2.1%										
	Benefit /Cost Ratio		0.24										
Indirect Transportation													
Marine Atlantic Impacts													
	Passenger Vehicles												
		Base Projection # Vehicle trips	2.50%	260,288	266,795	273,465	280,302	287,309	294,492	301,854	309,401	317,136	325,064
		Vehicle trips diverted	10%	-26,029	-26,680	-27,347	-28,030	-28,731	-29,449	-30,185	-30,940	-31,714	-32,506
		Net Vehicle trips		234,259	240,116	246,119	252,272	258,578	265,043	271,669	278,461	285,422	292,558
		Passenger Vehicle Revenue $	148	34,670,383	35,537,143	36,425,571	37,336,210	38,269,615	39,226,356	40,207,015	41,212,190	42,242,495	43,298,557
	Freight tractor trailer												
		Base Projection Tractor-trailer	2/3	159,431	163,417	167,523	171,710	176,004	180,404	184,914	189,537	194,275	199,132
		Diverted Freight tractor trailer	1	-23,918	-24,516	-25,128	-25,757	-26,401	-27,061	-27,737	-28,430	-29,141	-29,870
		Net Freight tractor trailer		135,513	138,901	142,394	145,954	149,603	153,343	157,177	161,106	165,134	169,262
		Net Revenue $	257.23	34,861,854	35,737,381	36,630,938	37,546,712	38,485,380	39,447,514	40,433,702	41,444,544	42,480,658	43,542,674
		Change in Pass. Car Equivalent Veh. (PCU)		2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
	Total Operating Cost		311	131,767,579	133,233,891	134,723,155	136,220,394	137,736,415	139,300,906	140,864,239	142,446,670	144,048,434	145,669,774

				Phase 3 - Operation									
				32	33	34	35	36	37	38	39	40	41
Traffic	Travellers (one-way trips)	Tourist Visitors - ferry/link	3.50%	37,765	39,087	40,455	41,871	43,337	44,853	46,423	48,048	49,730	51,470
		Traditional Tourist Vehicles		14,144	14,639	15,152	15,682	16,231	16,799	17,387	17,995	18,625	19,277
		Induced Visitors - fixed Link	1.25%	10,828	11,815	12,865	13,981	15,169	16,431	17,772	19,197	20,709	22,315
		Induced Demand Vehicles - Tourists	2.67	4,056	4,425	4,818	5,236	5,681	6,154	6,656	7,190	7,756	8,358
		Tourist Vehicles - ferry/link	2.67	18,200	19,064	19,970	20,919	21,912	22,953	24,043	25,185	26,382	27,633
	Passenger Veh												
	Labrador	Local and Business Traffic Base	1.5%	36,472	37,019	37,574	38,138	38,710	39,290	39,880	40,478	41,085	41,701
		one-time surge	30.0%										
	Cabot	Diverted Passenger Vehicles		33,319	34,152	35,006	35,881	36,778	37,697	38,640	39,606	40,596	41,611
		Induced Demand Veh %	1.50%	8,216	8,339	8,464	8,591	8,720	8,851	8,984	9,118	9,255	9,394
		One time effect	30.0%										
	Total	Total Passenger Vehicles		100,262	103,000	105,832	108,765	111,801	114,946	118,203	121,578	125,074	128,699
		Total Induced Vehicle Trips		12,272	12,764	13,283	13,828	14,401	15,005	15,640	16,308	17,011	17,752
		Total Visitors	2.67	267,700	275,009	282,573	290,403	298,510	306,905	315,602	324,612	333,949	343,626
	Base Freight												
		Cabot/Oceanex Tractor trailer	2.50%	306,165	313,819	321,665	329,707	337,949	346,398	355,058	363,934	373,033	382,358
		Apollo Tractor-trailer		5,169	5,298	5,431	5,567	5,706	5,848	5,995	6,144	6,298	6,455
		Diverted Cabot/Oceanex Tractor-Trailer	10%	30,617	31,382	32,166	32,971	33,795	34,640	35,506	36,393	37,303	38,236
		Induced Cabot/Oceanex Tractor-Trailer	1.0%	3,062	3,138	3,217	3,297	3,379	3,464	3,551	3,639	3,730	3,824
		Total Tractor trailer		38,847	39,819	40,814	41,834	42,880	43,952	45,051	46,177	47,332	48,515
	Design Peak Hour Vol	Autos		63	64	66	68	70	72	74	76	78	80
		Trucks		14	14	14	15	15	16	16	16	17	17
		PCUs	2.5	97	100	102	105	108	111	114	117	120	123
		Dominant Direction (ratio)	50.00%	49	50	51	53	54	55	57	58	60	62
Revenue Total				35,300,210	35,586,011	35,880,243	36,182,190	36,495,150	36,816,430	37,147,348	37,488,237	37,839,440	38,201,316
	Passenger Tolls			1,674,381	1,720,093	1,767,403	1,816,376	1,867,083	1,919,596	1,973,990	2,030,345	2,088,742	2,149,269
	Vehicle Tolls			3,058,001	3,141,487	3,227,891	3,317,334	3,409,943	3,505,849	3,605,193	3,708,113	3,814,760	3,925,293
	Freight Tolls			6,264,116	6,420,718	6,581,236	6,745,767	6,914,412	7,087,272	7,264,454	7,446,065	7,632,217	7,823,022
	Transmission Fee			17,198,000	17,198,000	17,198,000	17,198,000	17,198,000	17,198,000	17,198,000	17,198,000	17,198,000	17,198,000
	Cable recovery			7,105,712	7,105,712	7,105,712	7,105,712	7,105,712	7,105,712	7,105,712	7,105,712	7,105,712	7,105,712
	Other												
Expenses Total				4,966,206	4,966,206	4,966,206	4,966,206	8,096,206	4,966,206	4,966,206	4,966,206	4,966,206	10,829,206
	Operations												
		Wages		3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000	3,374,000
		Energy		892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206	892,206
	Annual Maintenance												
		Wages		614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000	614,000
		Purchased Serv & Supp		86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000
	Periodic Maintenance												
		Purchased Serv & Supp						3,130,000					5,863,000
Gross Operating (Surplus/Deficit)				30,334,004	30,619,805	30,914,036	31,216,984	28,398,944	31,850,224	32,181,142	32,522,031	32,873,234	27,373,110
Total Capital Investments (Outflow)	Pre-operation		1,261,466,303										
	Operations Phase		0	0	0	0	0	0	0	0	0	0	0
	Infrastructure												
		Civil Works	971,740,348										
		M & E	13,304,000										
		Systems	29,612,411										
		Rolling Stock	31,867,772										
		Cable	71,300,200										
	Sub total		1,115,784,783										
	Other (Design, Proj. Mgt)		178,681,519										
TOTAL CAPEX		$ 2004	1,261,466,303										
Present Values at Social Discount Rate	Present Value Income Operation Phase		175,508,861	3,489,044	3,271,900	3,068,793	2,879,794	2,701,036	2,534,711	2,379,064	2,233,392	2,097,037	1,969,389
	Present Value Cost Operation Phase		-30,867,079	490,856	456,610	424,751	395,120	599,307	341,910	318,050	295,866	275,224	398,103
	Present Value Capital Investment		-699,069,609										
	Net Present Value of Fixed Link Cash Flows		-554,427,827										
Benefit Cost Ratio and IRR	Fixed Link Cash Flows	sum undiscounted	-432,951,286	30,334,004	30,619,805	30,914,036	31,216,984	28,398,944	31,850,224	32,181,142	32,522,031	32,873,234	27,373,110
	Real Internal Rate of Return (RIRR)		-2.1%										
	Benefit /Cost Ratio		0.24										
Indirect Transportation													
Marine Atlantic Impacts													
	Passenger Vehicles												
		Base Projection # Vehicle trips	2.50%	333,191	341,521	350,059	358,810	367,780	376,975	386,399	396,059	405,961	416,110
		Vehicle trips diverted	10%	-33,319	-34,152	-35,006	-35,881	-36,778	-37,697	-38,640	-39,606	-40,596	-41,611
		Net Vehicle trips		299,872	307,369	315,053	322,929	331,002	339,277	347,759	356,453	365,365	374,499
		Passenger Vehicle Revenue $	148	44,381,021	45,490,547	46,627,810	47,793,506	48,988,343	50,213,052	51,468,378	52,755,087	54,073,965	55,425,814
	Freight tractor trailer												
		Base Projection Tractor-trailer	2/3	204,110	209,213	214,443	219,804	225,299	230,932	236,705	242,623	248,688	254,906
		Diverted Freight tractor trailer	1	-30,617	-31,382	-32,166	-32,971	-33,795	-34,640	-35,506	-36,393	-37,303	-38,236
		Net Freight tractor trailer		173,494	177,831	182,277	186,834	191,505	196,292	201,199	206,229	211,385	216,670
		Net Revenue $	257.23	44,631,241	45,747,022	46,890,698	48,062,965	49,264,540	50,496,153	51,758,557	53,052,521	54,378,834	55,738,305
		Change in Pass. Car Equivalent Veh. (PCU)		2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
	Total Operating Cost		311	147,310,932	148,972,156	150,633,694	152,355,800	154,078,730	155,822,743	157,588,100	159,375,069	161,183,916	163,014,916

Economic Methodology for Fixed Link Project

Phase 3 - Operation

				22	23	24	25	26	27	28	29	30	31
		Wages	64.3	77,945,346	78,919,663	79,906,158	80,904,985	81,916,298	82,940,251	83,977,004	85,026,717	86,089,551	87,165,670
		Fuel	16.9	17,572,041	17,615,971	17,660,011	17,704,161	17,748,422	17,792,793	17,837,275	17,881,868	17,926,573	17,971,389
		Purchased Goods & Ser	29.9	36,245,192	36,698,257	37,156,985	37,621,447	38,091,715	38,567,862	39,049,960	39,538,085	40,032,311	40,532,715
	Subsidy Impact	-- reference subsidy $mm	43.8										
		Incremental gain (loss)		-10,005,063	-10,255,189	-10,511,569	-10,774,358	-11,043,717	-11,319,810	-11,602,805	-11,892,875	-12,190,197	-12,494,952
	Net Revenue	Operating Surplus(deficit)		-62,226,342	-61,959,248	-61,666,646	-61,347,672	-61,001,440	-60,627,036	-60,223,523	-59,789,935	-59,325,282	-58,828,542
	Capital Plan - Base	$ Millions											
	Capital Plan - Divert	$ Millions		150									
	Total Cash - Base			-52,221,279	-51,704,059	-51,155,077	-50,573,314	-49,957,723	-49,307,226	-48,620,718	-47,897,060	-47,135,084	-46,333,590
	Total Cash - Divert			-212,226,342	-61,959,248	-61,666,646	-61,347,672	-61,001,440	-60,627,036	-60,223,523	-59,789,935	-59,325,282	-58,828,542
	PV Base (2004)		-1,044,206,082	-10,638,032	-9,797,231	-9,017,489	-8,292,965	-7,620,484	-6,996,519	-6,417,773	-5,881,165	-5,383,818	-4,923,042
	PV Divert		-1,015,598,330	-43,232,771	-11,741,172	-10,870,441	-10,059,734	-9,305,078	-8,602,760	-7,949,305	-7,341,463	-6,776,195	-6,250,657
	Net Present Value	Benefit attributable to fixed link	28,607,753										
Apollo Impacts													
	Base												
		Total Vehicles #	2.50%										
		Trucks # (est.)	10.00%										
		Passenger Vehicles #											
	Subsidy impact	Reference Annual Subsidy $ millions	5.5										
		Sub total											
	Net Charge	Surplus(deficit)		-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0
	Capital Plan - Base												
	Capital Plan - Divert												
	Total Cash - Base			-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000
	Total Cash - Divert			0	0	0	0	0	0	0	0	0	0
	PV Base (2004)		-110,098,784	-1,120,409	-1,043,241	-969,328	-901,885	-838,983	-780,430	-725,987	-675,352	-628,216	-584,387
	PV Divert		-49,938,711	0	0	0	0	0	0	0	0	0	0
	Net Present Value	Benefit attributable to fixed link	60,160,073										
Transportation Net Present Value - ERR and Benefit to Cost Ratio	Fix Link Cash Flows			27,883,974	27,039,012	28,320,183	28,547,624	28,781,560	13,200,302	29,269,770	29,524,494	29,786,609	6,178,360
	Marine Atlantic Economic Benefit			-160,005,063	-10,255,189	-10,511,569	-10,774,358	-11,043,717	-11,319,810	-11,602,805	-11,892,875	-12,190,197	-12,494,952
	Apolo Economic Benefit			5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000
	Total Economic Cash Flow		-226,729,066	-126,621,089	22,283,843	23,308,615	23,273,266	23,237,843	7,380,392	23,166,965	23,131,618	23,096,411	-816,592
		Present Value	-465,660,902	-25,794,067	4,222,750	4,108,784	3,816,329	3,544,669	1,047,251	3,017,962	2,840,276	2,638,096	-86,765
	Economic Net Present Value		-465,660,902										
	Economic Rate of Return (ERR)		-1.1%										
	Benefit /Cost Ratio		0.38										
Other Economic Impacts			432,712,179	-115,759,219	33,489,178	34,563,205	34,731,286	34,903,901	21,489,548	35,264,706	35,453,070	35,647,077	15,334,096
	Construction Impacts	Indirect plus induced GDP -- NPV	166,971,243										
	Operations Impacts	Indirect plus induced GDP -- NPV	4,350,097										
	Tourism Impacts	Total GDP Impact -- NPV	54,374,372										
	Total Spin-off Benefits	NPV	225,695,712										
	Fixed Link Economic NPV		-239,964,289										
		Socio-economic Rate of Return	2.3%										
		Benefit Cost Ratio	0.70										
SECTION 2 - Financial Analysis													
		Project Cost, Constant 2004$		27,883,974	27,039,012	28,320,183	28,547,624	28,781,560	13,200,202	29,269,770	29,524,494	29,786,609	6,178,360
		Nominal Value		48,004,252	47,713,365	51,223,451	52,925,700	54,693,388	25,711,394	58,436,951	60,419,142	62,479,424	13,283,517
Financing during Construction	Cumul. Const. Cost	Comprised of:	-1,812,607,275										
		Interest during Construction (IDC)	-262,569,603										
		Project Costs	-1,550,037,672										
Financing Base Case	Project Cost												
Debt Financing		Pre operations cost	1,550,037,672										
		Interest during Construction	262,569,603										
	Total Amount to Finance		1,812,607,275										
		Annual Debt Amortization (CRF)	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730
		Net Cash Flow		-152,340,478	-152,631,364	-149,121,279	-147,419,030	-145,651,341	-174,633,376	-141,907,779	-139,925,587	-137,865,305	-187,061,213
		Internal Rate of Return	0.4%										
Subsidized Financing Sensitivity Case		Project Spending	1,550,037,672										
		Grant Award	1,050,000,000										
		Cost less Grant	500,037,672										
	Total Amount to Finance		536,566,842										
		Comprised of:											
		Interest during Construction (IDC)	36,529,170										
		Project Costs	500,037,672										

		32	33	34	35	36	37	38	39	40	41
	Wages	88,255,241	89,358,432	90,475,412	91,606,355	92,751,434	93,910,827	95,084,713	96,273,271	97,476,687	98,695,146
	Fuel	18,016,318	18,061,358	18,106,512	18,151,778	18,197,158	18,242,650	18,288,257	18,333,978	18,379,813	18,425,762
	Purchased Goods & Ser	41,039,373	41,552,366	42,071,770	42,597,667	43,130,138	43,669,265	44,215,131	44,767,820	45,327,418	45,894,010
Subsidy Impact	-- reference subsidy $mm										
	Incremental gain (loss)	-12,807,326	-13,127,509	-13,455,697	-13,792,089	-14,136,892	-14,490,314	-14,852,572	-15,223,886	-15,604,483	-15,994,595
Net Revenue	Operating Surplus(deficit)	-58,298,670	-57,734,587	-57,135,186	-56,499,329	-55,825,847	-55,113,538	-54,361,165	-53,567,461	-52,731,119	-51,850,800
Capital Plan - Base	$ Millions			75			100				150
Capital Plan - Divert	$ Millions									75	
Total Cash - Base		-45,491,344	-44,607,078	-118,679,489	-42,707,240	-41,688,956	-140,623,224	-39,508,594	-38,343,575	-37,126,626	-185,856,205
Total Cash - Divert		-58,298,670	-57,734,587	-57,135,186	-56,499,329	-55,825,847	-55,113,538	-54,361,165	-53,567,461	-127,731,119	-51,850,800
PV Base (2004)		-4,496,327	-4,101,328	-10,150,510	-3,397,858	-3,085,434	-9,681,327	-2,530,298	-2,284,349	-2,057,534	-9,581,423
PV Divert		-5,762,193	-5,308,316	-4,886,702	-4,495,180	-4,131,717	-3,794,417	-3,481,506	-3,191,324	-7,078,776	-2,673,058
Net Present Value	Benefit attributable to fixed link										
Net Charge	Surplus(deficit)	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000.0	-5,500,000
Capital Plan - Base										75	
Capital Plan - Divert											
Total Cash - Base		-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-5,500,000	-80,500,000	-5,500,000
Total Cash - Divert		0	0	0	0	0	0	0	0	0	0
PV Base (2004)		-543,610	-505,689	-470,408	-437,589	-407,060	-378,660	-352,242	-327,667	-4,461,258	283,541
PV Divert		0	0	0	0	0	0	0	0	0	0
Fix Link Cash Flows		30,334,004	30,619,805	30,914,036	31,216,984	28,398,944	31,850,224	32,181,142	32,522,031	32,873,234	27,373,110
Marine Atlantic Economic Benefit		-12,807,326	-13,127,509	61,544,303	-13,792,089	-14,136,892	85,509,686	-14,852,572	-15,223,886	-90,604,483	134,005,405
Apolo Economic Benefit		5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000	80,500,000	5,500,000
Total Economic Cash Flow		23,026,678	22,992,296	97,958,339	22,924,895	19,762,053	122,859,910	22,828,570	22,798,145	22,768,751	166,878,515
	Present Value	2,275,938	2,113,990	8,378,256	1,823,942	1,462,606	8,458,571	1,462,033	1,358,218	1,261,829	8,603,069
Other Economic Impacts		36,053,002	36,265,442	111,484,571	36,710,682	34,255,190	137,185,103	37,434,077	37,691,362	37,957,335	183,198,518
	Project Cost, Constant 2004$	30,334,004	30,619,805	30,914,036	31,216,984	28,398,944	31,850,224	32,181,142	32,522,031	32,873,234	27,373,110
	Nominal Value	66,848,772	69,165,572	71,575,957	74,084,108	69,081,434	79,813,714	82,244,779	85,193,881	88,266,732	73,336,012
	Annual Debt Amortization (CRF)	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730	-200,344,730
	Net Cash Flow	-133,495,957	-131,179,158	-128,768,777	-126,260,421	-131,263,295	-120,531,016	-118,099,951	-115,150,848	-112,077,998	-127,008,718

Economic Methodology for Fixed Link Project				Phase 3 - Operation																			
				22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
		Internal Rate of Return	7.6%	48,004,252	47,713,365	51,223,451	52,975,700	54,693,388	25,711,354	58,436,951	60,419,142	62,479,424	13,282,517	66,848,772	69,165,572	71,575,952	74,084,308	69,081,434	79,412,714	82,244,779	85,193,881	88,266,732	75,336,012
Section 3 - Socio-Economic Impact				22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Construction Effects																							
	Construction Spending	Annual Civil & M&E																					
		Direct GDP	34.0%																				
		Indirect	63.0%																				
		Induced	15.0%																				
		Indirect plus induced GNP impact																					
		Net Present Value	166,971,243																				
Operations Impacts	Operations Costs	Annual Costs		4,966,206	6,020,206	4,966,206	4,966,206	4,966,206	20,788,206	4,966,206	4,966,206	4,966,206	28,844,206	4,966,206	4,966,206	4,966,206	4,966,206	8,096,206	4,966,206	4,966,206	4,966,206	4,966,206	10,828,206
		Direct GDP	34.0%	1,688,510	2,048,910	1,688,510	1,688,510	1,688,510	7,067,990	1,688,510	1,688,510	1,688,510	9,807,030	1,688,510	1,688,510	1,688,510	1,688,510	2,752,710	1,688,510	1,688,510	1,688,510	1,688,510	3,681,590
		Indirect	23.0%	388,357	471,249	388,357	388,357	388,357	1,625,638	388,357	388,357	388,357	2,255,617	388,357	388,357	388,357	388,357	633,123	388,357	388,357	388,357	388,357	846,766
		Induced	15.0%	311,530	378,024	311,530	311,530	311,530	1,304,044	311,530	311,530	311,530	1,809,397	311,530	311,530	311,530	311,530	507,875	311,530	311,530	311,530	311,530	679,253
		Indirect plus induced GNP impact		699,887	849,273	699,887	699,887	699,887	2,929,682	699,887	699,887	699,887	4,065,014	699,887	699,887	699,887	699,887	1,140,998	699,887	699,887	699,887	699,887	1,526,019
		Net Present Value	4,350,097	142,575	160,936	123,374	114,767	106,760	415,711	92,383	85,938	79,942	431,916	69,176	64,350	59,861	55,684	84,446	48,185	44,824	41,696	38,787	78,671
Tourism Impacts	Tourist Indicators																						
		Induced Visitors – trip add-on	1	73,276	75,528	77,859	80,273	82,773	85,363	88,046	90,826	93,708	96,694	99,790	103,001	106,330	109,784	113,366	117,083	120,941	124,945	129,101	133,416
		Induced Visitors – full trip	11	18,902	19,186	19,473	19,765	20,062	20,363	20,668	20,978	21,293	21,612	21,937	22,266	22,600	22,939	23,283	23,632	23,986	24,346	24,711	25,082
		Incremental Room nights	2	140,599	143,285	146,033	148,847	151,727	154,677	157,699	160,794	163,965	167,215	170,546	173,961	177,463	181,054	184,738	188,517	192,396	196,376	200,463	204,659
		Incr. Annual Expenditures Tourists	62.35	17,532,751	17,867,598	18,210,323	18,561,171	18,920,394	19,288,257	19,665,034	20,051,008	20,446,477	20,851,749	21,267,143	21,692,994	22,129,648	22,577,467	23,036,827	23,508,119	23,991,751	24,488,147	24,997,751	25,521,022
		Direct GDP	35.0%	6,136,463	6,253,659	6,373,613	6,496,410	6,622,138	6,750,890	6,882,762	7,017,853	7,156,267	7,298,112	7,443,500	7,592,548	7,745,377	7,902,114	8,062,889	8,227,842	8,397,113	8,570,852	8,749,213	8,932,358
		Indirect	44.0%	2,700,044	2,751,610	2,804,390	2,858,420	2,913,741	2,970,392	3,028,415	3,087,855	3,148,757	3,211,169	3,275,140	3,340,721	3,407,966	3,476,930	3,547,671	3,620,250	3,694,730	3,771,175	3,849,654	3,930,237
		Induced	15.0%	1,325,476	1,350,790	1,376,700	1,403,225	1,430,382	1,458,192	1,486,677	1,515,856	1,545,754	1,576,392	1,607,796	1,639,990	1,673,001	1,706,857	1,741,584	1,777,214	1,813,776	1,851,304	1,889,830	1,929,389
		Total		10,161,982	10,356,060	10,554,703	10,758,055	10,966,261	11,179,474	11,397,854	11,621,564	11,850,778	12,085,673	12,326,436	12,573,259	12,826,344	13,085,900	13,352,145	13,625,306	13,905,619	14,193,330	14,488,698	14,791,984
		Net Present Value	54,374,372	2,070,104	1,962,456	1,860,557	1,764,096	1,672,779	1,586,327	1,504,479	1,426,984	1,353,608	1,284,128	1,218,335	1,156,029	1,097,021	1,041,136	988,203	938,065	890,571	845,579	802,954	762,569
TOTAL OTHER IMPACTS		Net Present Value - Real	225,695,712	2,212,679	2,123,392	1,983,931	1,878,863	1,779,539	2,002,039	1,596,862	1,512,922	1,433,550	1,716,045	1,287,511	1,220,379	1,156,882	1,096,820	1,072,650	986,251	935,395	887,275	841,741	841,240
Social Impacts																							
	Employment	Construction & Operations																					
		NL - Skilled		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
		NL - Unskilled		15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
		Non res		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Total NL Direct Employment		40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
		Indirect Construction Employment	0.63	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
		Induced Construction Employment	0.3	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
		Total Annual FTE Employment		85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
		Tourism																					
		Total Incremental Spending		17,532,751	17,867,598	18,210,323	18,561,171	18,920,394	19,288,257	19,665,034	20,051,008	20,446,477	20,851,749	21,267,143	21,692,994	22,129,648	22,577,467	23,036,827	23,508,119	23,991,751	24,488,147	24,997,751	25,521,022
		Incremental FTE - Direct	12.8	224	229	233	238	242	247	252	257	262	267	272	278	283	289	295	301	307	313	320	327
		Incremental FTE - Indirect	0.24																				
		Incremental FTE - Induced	0.15																				
		Total Impact	18.3	320	326	332	339	345	352	359	366	373	381	388	396	404	412	420	429	438	447	456	466
		TOTAL RELATED EMPLOYMENT		405	411	417	424	430	437	444	451	458	465	473	481	489	497	505	514	523	532	541	551
	Wages	Construction & Operations																					
		Direct Payroll		3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000	3,988,000
		Indirect Construction Employment	0.53	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640	2,113,640
		Induced Construction Employment	0.3	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492	1,830,492
		Sub-Total Wages		7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132	7,932,132
		Tourism																					
		Incremental Direct Wages	23.6%	4,137,729	4,216,753	4,297,636	4,380,436	4,465,213	4,552,029	4,640,948	4,732,038	4,825,369	4,921,013	5,019,046	5,119,547	5,222,597	5,328,282	5,436,691	5,547,916	5,662,053	5,779,203	5,899,469	6,022,961
		Incremental Indirect Wages	33.0%																				
		Incremental Induced Wages	15.0%																				
		Sub-Total Wages	30.1%	6,328,657	6,449,524	6,573,235	6,699,877	6,829,543	6,962,328	7,098,330	7,237,652	7,380,401	7,526,689	7,676,630	7,830,346	7,987,962	8,149,608	8,315,419	8,485,538	8,660,110	8,839,291	9,023,238	9,212,119
		TOTAL RELATED WAGES		14,260,789	14,381,656	14,505,367	14,632,009	14,761,675	14,894,460	15,030,462	15,169,784	15,312,533	15,458,821	15,608,762	15,762,478	15,920,094	16,081,740	16,247,551	16,417,670	16,592,242	16,771,423	16,955,370	17,144,251
		NPV Wages	411,233,763	2,905,079	2,715,290	2,556,970	2,390,343	2,261,728	2,113,471	1,983,971	1,862,661	1,749,013	1,642,553	1,542,757	1,449,256	1,361,626	1,279,490	1,202,495	1,130,312	1,062,633	999,171	939,656	883,836
	Other Impacts																						

ECONOMIC ANALYSIS WORKSHEETS – UPGRADED FERRY

Economic Methodology for Fixed Link Project

Section 1 - Transportation Economics

			Rate	Phase 1 - Planning Approval 1	2	3
Traffic	Travellers (one way input)	Tourist Visitors - ferry/link	3.00%	13,000	13,433	13,916
		Traditional Tourist Vehicles		4,869	5,019	5,216
		Induced Visitors - fixed Link	0.30%			
		Induced Demand Vehicles - Tourists	2.67			
		Tourist Vehicles - ferry/link	2.67	4,869	5,019	5,216
	Passenger Veh. Labrador	Local and Business Traffic Base	1.2%	16,280	16,467	17,012
		Induced Demand - Local	11.0%			
	Cabot	Diverted Passenger Vehicles				
		Induced Demand Veh's	0.00%	0	0	0
	Total	Total Passenger Vehicles		21,127	21,486	22,229
		Total Induced Vehicle Trips		0	0	0
		Total Visitors	2.67	36,493	37,980	39,349
	Base Freight	Cabot/Gateway Tractor-trailer	2.50%	143,003	145,963	149,611
		Apollo Tractor-trailer		2,882	2,917	3,031
		Diverted Cabot/Gateway Tractor-Trailer	2%			
		Induced Cabot/Gateway Tractor-Trailer	0.0%	0	0	0
		Total Tractor-trailer		2,882	2,917	3,031
	Design Peak Trip Vol	Autos		68	68	69
		Trucks		1	1	1
		PCU's		68	71	73
		Dominant Direction (ratio)	30.00%	35	35	36
Revenue Total		Total Rev		1,461,922	1,500,410	1,517,928
	Passenger Tolls			[illegible]	[illegible]	[illegible]
	Vehicle Tolls			[illegible]	[illegible]	[illegible]
	Freight Tolls			[illegible]	[illegible]	[illegible]
	Passenger Tolls	Incremental				
	Vehicle Tolls	Incremental				
Expenses Total	Freight Tolls	Incremental				
	Total	Incremental		0	0	0
Total Capital Investments (Outflow)	Pre-operation		0			
	Operations Phase Infrastructure		0			
		Civil Works	0			
		M & E	0			
		Systems	0			
		Rolling Stock	0			
	Sub total		0			
	Other (Design, Eng, Mgt)		0			
TOTAL CAPEX		$ 2004	0			
Present Values at Social Discount Rate	Present Value Total Revenue over service		23,077,899			
	Present Value Capital Investment		0	0	0	0
	Net Present Value		-163,608,799			
Benefit Cost Ratio and IRR	Benefit /Cost Ratio		0.13			

Indirect Transportation

			Rate	1	2	3
Marine Atlantic Impacts	Passenger Vehicles					
		Base Projection # Vehicle trips	2.50%	154972	158,846	162,817
		Vehicle-trips diverted	1%			
		Net Vehicle trips				
		Passenger Vehicle Revenue $	148	22,935,856	23,509,252	24,096,984
	Freight tractor-trailer	Base Projection Tractor trailer	2?3	94,933	97,308	99,741
		Diverted Freight tractor-trailer	1			
		Net Freight tractor-trailer				
		Net Revenue $	257.33	24,431,943	25,042,692	25,658,300
		Change in Pass. Car Equivalent Veh. (PCU)			2.5%	2.5%
	Total Operating Cost		111	111,100,000	112,319,730	113,550,320
		Wages	64.3	64,230,000	65,103,730	65,917,547
		Fuel	16.9	16,900,000	16,643,250	16,984,806
		Purchased Goods & Ser	29.9	29,900,000	30,273,750	30,652,172
	Subsidy impact	- in/excess subsidy $ mm	43.8			
		Incremental gain ($mm)				
	Net Revenue	Operating Surplus(deficit)		-63,742,201	-63,770,000	-63,795,037
	Capital Plan - Base	$ Millions				
	Capital Plan - Divert	$ Millions				
	Total Cash - Base			-63,742,201	-63,770,000	-63,795,037
	Total Cash - Divert			-63,742,201	-63,770,000	-63,795,037
	PV Base (2004)		-1,078,474,109	-59,293,071	-33,109,195	-51,233,799
	PV Divert		-1,098,561,306	-59,293,071	-33,109,195	-51,233,799
	Net Present Value	Benefit attributable to fixed link	-9,303,197	0	0	0
Apollo Impacts	Base					
		Total Vehicles #	2.30%	20002	20441	22229
		Trucks (5 yr)	17.00%	2,899	2,913	3,031

Economic Methodology for Fixed Link Project				Phase 1 - Planning Approval			Phase 2 - Design & Construction																					
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		Passenger Vehicles #		21,037	21,684	22,229	22,784	23,333	23,937	24,536	25,149	25,778	26,422	27,083														
	Diversions Freight																											
		Tractor trailer																										
		Drop trailer																										
		Truck																										
		Revenue $																										
	Operating Cost																											
		Wages																										
		Fuel																										
	Subsidy impact	Reference Annual Subsidy $ millions	3.5																									
		Sub total																										
	Net Change	Surplus(deficit)		-3,500,000	-3,500,000	-3,500,000	-3,500,000	-3,500,000	-3,500,000	-3,500,000	-3,500,000	-3,500,000	-3,500,000	-3,500,000	-3,500,000.0	-3,500,000.0	-3,500,000.0	-3,500,000.0	-3,500,000.0	-3,500,000.0	-3,500,000.0	-3,500,000.0	-3,500,000.0	-3,500,000.0	-3,500,000.0	-3,500,000.0	-3,500,000.0	-3,500,000.0
	Capital Plan - Base												75															
	Capital Plan - Divert		3										150															
	Capital NPV/BAGs		40,545,996	0	0	0	0	0	0	0	0	0	36,189,545	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Capital NPV New		81,091,992	0	0	0	0	0	0	0	0	0	32,719,096	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Operating Costs Status Quo		3,500,000	6,961,827	7,000,418	7,037,978	7,079,370	7,115,786	7,156,180	7,197,583	7,240,023	7,283,125	7,328,113	7,373,816	9,060,131	9,140,350	9,222,445	9,306,561	9,392,718	9,480,969	9,571,365	9,663,963	9,758,822	9,856,083	9,955,566	10,057,570	10,162,037	10,269,126
	Operating Costs New Service		30.0%	10,443,733	10,500,627	10,558,092	10,614,564	10,673,879	10,734,271	10,796,377	10,860,037	10,925,788	10,992,170	14,747,637	18,120,262	18,289,020	18,444,990	18,612,122	18,783,436	18,961,558	19,142,731	19,327,911	19,517,500	19,712,000	19,911,113	20,117,113	20,324,113	20,538,237
	PV Base (2004)		33,193,841	6,477,974	6,037,640	5,663,259	5,208,796	4,956,302	4,630,930	4,338,200	4,019,098	3,799,966	3,533,836	3,328,127	3,803,031	3,569,081	3,350,629	3,131,501	2,933,963	2,772,578	2,601,693	2,445,611	2,297,356	2,158,136	2,028,024	1,901,890	1,791,142	1,683,022
	PV Divert		100,281,632												7,037,867	7,139,722	6,901,177	6,290,603	5,865,897	5,545,473	5,267,767	4,899,203	4,594,711	4,316,712	4,036,108	3,811,780	3,597,684	3,367,543
	NPV	Capital	-40,545,996																									
	Net Present Value	Ferry upgrade net cost	-33,193,841																									
	Economic Net Present Value		-79,231,149																									
	Benefit /Cost Ratio		0.56																									
Other Economic Impacts			12,707,594	0	0	0	0	0	0	0	0	0	0	0	280,830	291,644	305,396	317,959	320,657	328,364	335,073	343,994	323,930	303,229	371,172	386,318	399,731	399,350
	Construction Impacts	Indirect plus Induced GDP – NPV	0																									
	Operations Impacts	Indirect plus Induced GDP – NPV	582,900																									
	Tourism Impacts	Total GDP Impact – NPV	1,406,900																									
	Total Spin-off Benefits	NPV	1,989,894																									
	Fixed Link Economic NPV		-77,241,255																									
		Socio-economic Rate of Return	#NUM!																									
		Benefit Cost Ratio	0.59																									
	SECTION 2 - Financial Analysis																											
		Project Cost, Constant 2004$		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Nominal Value		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Financing during Construction	Comm. Const. Cap	Comprised of:	0	0	0	0	0	0	0	0	0	0	0	0														
		Interest during Construction (IDC)	0	0	0	0	0	0	0	0	0	0	0	0														
		Project Costs	0																									
Financing Base Case Debt Financing	Project Cost																											
		Pre operations cost	0																									
		Interest during Construction	0																									
	Total Amount to Finance		0																									
		Annual Debt Amortization (CRF)	0												0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Net Cash Flow													0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Internal Rate of Return	#NUM!																									
Subsidized Financing Sensitivity Case		Project Spending	0	0	0	0	0	0	0	0	0	0	0	0														
		Grant Award	0	0	0	0	0	0	0	0	0	0	0	0														
		Cost less Grant	0	0	0	0	0	0	0	0	0	0	0	0														
	Total Amount to Finance		0																									
		Comprised of:		0	0	0	0	0	0	0	0	0	0	0														
		Interest during Construction (IDC)	0	0	0	0	0.00	0	0	0	0	0	0	0														
		Project Costs	0																									
		Internal Rate of Return	#NUM!	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Section 3 - Socio-Economic Impact			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Construction Effects																												
	Construction Spending	Annual Civil & M&E		0	0	0	0	0	0	0	0	0	0	0														
		Direct GDP	34.0%	0	0	0	0	0	0	0	0	0	0	0														
		Indirect	63.0%	0	0	0	0	0	0	0	0	0	0	0														
		Induced	13.0%	0	0	0	0	0	0	0	0	0	0	0														
		Indirect plus Induced GNP Impact		0	0	0	0	0	0	0	0	0	0	0														
		Net Present Value	0	0	0	0	0	0	0	0	0	0	0	0														
Operations Impacts	Operations Costs	Annual Costs													607,571	617,635	623,676	643,053	663,120	681,734	698,749	716,268	734,174	752,529	771,342	790,626	810,391	830,651
		Direct GDP	34.0%												204,874	209,996	215,248	220,627	226,143	231,796	237,591	243,531	249,619	255,860	262,256	268,813	275,533	282,421
		Indirect	22.0%												47,121	48,299	49,507	50,744	52,013	53,313	54,646	56,012	57,412	58,849	60,319	61,827	63,373	64,957
		Induced	13.0%												37,799	38,744	39,713	40,706	41,723	42,766	43,836	44,931	46,055	47,206	48,386	49,596	50,836	52,107
		Indirect plus Induced GNP Impact													84,920	87,043	89,219	91,450	93,736	96,080	98,482	100,944	103,467	106,054	108,705	111,423	114,209	117,064
		Net Present Value	102,300												35,634	33,998	32,413	30,907	29,449	28,059	26,732	25,568	24,338	23,222	22,144	21,114	20,132	19,196
Tourism Impacts	Tourist Indicators																											
		Induced Visitors – trip add-on	1												5,699	5,839	5,982	6,129	6,279	6,433	6,591	6,753	6,919	7,089	7,263	7,441	7,624	7,812
		Induced Visitors – full trip	11												0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Incremental Room nights	2	6,300	6,729	6,983	7,207	7,430	7,720	7,990	8,270	8,335	8,834	9,149	2,849	2,919	2,991	3,064	3,140	3,217	3,296	3,376	3,459	3,544	3,631	3,721	3,812	3,906
		New Annual Expenditure Tourism	62.33												355,330	364,003	372,975	382,126	391,503	401,112	410,959	421,049	431,388	441,984	452,841	463,967	475,367	487,051
		Direct GDP	33.0%												124,362	127,416	130,241	133,744	137,078	140,389	143,933	147,387	151,006	154,656	158,456	162,388	166,379	170,460
		Indirect	44.0%												54,721	56,053	57,420	58,847	60,292	61,771	63,280	64,847	66,434	68,063	69,737	71,431	73,207	75,006
		Induced	13.0%												26,863	27,527	28,197	28,899	29,599	30,326	31,068	31,831	32,563	33,414	34,233	35,076	35,938	36,821
		Total													205,309	211,996	216,126	221,493	226,913	232,483	238,192	244,040	250,033	256,174	262,467	268,915	275,523	282,296

Economic Methodology for Fixed Link Project

				Phase 1 - Planning Approval			Phase 2 - Design & Construction																					
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		Net Present Value	1,400,990												86,609	82,007	78,140	74,853	71,237	67,993	64,880	61,739	59,461	56,009	53,467	50,938	48,560	46,288
TOTAL OTHER IMPACTS		Net Present Value - Total	[illegible]	0	0	0	0	0	0	0	0	0	0	0	122,123	116,007	110,954	105,700	100,909	96,004	91,592	87,305	83,219	79,174	75,612	72,073	68,761	65,486
Social Impacts																												
	Employment	Construction & Operations																										
		NL - Skilled													23	23	23	23	23	23	23	23	23	23	23	23	23	23
		NL - Unskilled													13	13	13	13	13	13	13	13	13	13	13	13	13	13
		Non-res													0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Total NL Direct Employment													40	40	40	40	40	40	40	40	40	40	40	40	40	40
		Indirect Construction Employment	0.60												23	23	23	23	23	23	23	23	23	23	23	23	23	23
		Induced Construction Employment	0.3												20	20	20	20	20	20	20	20	20	20	20	20	20	20
		Total Annual FTE Employment													83	83	83	83	83	83	83	83	83	83	83	83	83	83
		Tourism																										
		Total Incremental Spending													355,380	364,643	372,973	387,126	391,301	401,112	410,912	421,045	431,388	441,994	452,841	463,967	475,267	[illegible]
		Incremental FTE - Direct	12.8												5	5	5	5	5	5	5	5	6	6	6	6	6	6
		Incremental FTE - Indirect	0.24																									
		Incremental FTE - Induced	0.13																									
		Total Impact	18.2												6	7	7	7	7	7	8	8	8	8	8	8	9	9
		TOTAL RELATED EMPLOYMENT													91	91	92	92	92	93	93	93	93	93	93	93	93	94
	Wages	Construction & Operations																										
		Direct Payroll													0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Indirect Construction Employment	0.33												0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Induced Construction Employment	0.2												0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Sub-Total Wages													0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Tourism																										
		Incremental Direct Wages	22.0%												83,030	85,915	88,022	91,187	92,193	94,663	96,996	99,368	101,808	104,289	106,879	109,496	112,187	114,944
		Incremental Indirect Wages	32.0%																									
		Incremental Induced Wages	13.0%																									
		Sub-Total Wages	80.1%												128,261	131,400	134,830	137,933	141,210	144,786	148,343	151,993	155,715	159,519	163,458	167,474	171,590	175,927
		TOTAL RELATED WAGES		0	0	0	0	0	0	0	0	0	0	0	128,264	131,400	134,836	137,933	141,210	144,786	148,343	151,993	155,715	159,519	163,458	167,474	171,590	175,927
		NPV Wages	970,341	0	0	0	0	0	0	0	0	0	0	0	53,851	51,311	48,913	46,617	44,438	42,343	40,356	38,462	36,657	34,937	33,298	31,736	30,247	28,829
	Other Impacts																											

Economic Methodology for Fixed Link Project

Phase 3 - Operation

Section 1 - Transportation Economics

				26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Traffic	Travellers (one-way trips)	Tourist Visitors - ferry/link	3.50%	30,722	31,797	32,910	34,062	35,254	36,488	37,765	39,087	40,455	41,871	43,337	44,853	46,423	48,048	49,730	51,470
		Traditional Tourist Vehicles		11,216	11,609	12,120	12,737	13,204	13,666	14,144	14,639	15,152	15,682	16,231	16,799	17,387	17,996	18,625	19,277
		Induced Visitors - fixed Link	0.50%	332	337	342	349	353	358	363	369	374	380	386	392	397	403	409	416
		Induced Demand Vehicles - Tourists	2.67	124	126	129	130	132	134	136	138	140	142	144	147	149	151	153	156
		Tourist Vehicles - ferry/link	2.67	11,631	12,036	12,434	12,888	13,336	13,800	14,280	14,778	15,292	15,824	16,375	16,946	17,536	18,147	18,779	19,433
	Passenger Veh. Labrador	Local and Business Traffic Base	1.5%	25,273	25,652	26,037	26,427	26,824	27,226	27,633	28,045	28,470	28,897	29,330	29,770	30,217	30,670	31,130	31,597
		Induced Demand - Local	15.0%	3,791	3,848	3,906	3,964	4,024	4,084	4,145	4,207	4,270	4,335	4,400	4,466	4,533	4,601	4,670	4,740
	Cabot	Diverted Passenger Vehicles		2,873	2,943	3,019	3,094	3,171	3,251	3,332	3,415	3,501	3,588	3,678	3,770	3,864	3,961	4,060	4,161
		Induced Demand Veh %	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	Total Passenger Vehicles		43,369	44,480	45,613	46,773	47,333	48,361	49,397	50,449	51,518	52,644	53,703	54,931	56,149	57,378	58,618	59,931
		Total Induced Vehicle Trips		2,998	3,073	3,147	3,224	3,303	3,385	3,458	3,553	3,661	3,730	3,822	3,916	4,013	4,112	4,213	4,317
		Total Visitors	2.67	116,126	118,762	121,229	123,916	126,437	129,126	131,877	134,699	137,349	140,359	143,001	146,720	149,910	153,199	156,166	160,013
	Base Freight	Cabot/Gateway Tractor-trailer	2.50%	264,001	270,603	277,371	284,303	291,413	298,698	306,163	313,819	321,663	329,707	337,949	346,399	355,058	363,934	373,033	382,358
		Apollo Tractor-trailer		5,349	5,482	5,619	5,760	5,904	6,052	6,203	6,358	6,517	6,680	6,847	7,018	7,193	7,373	7,558	7,747
		Diverted Cabot/Gateway Tractor-Trailer	2%	5,280	5,412	5,547	5,686	5,828	5,974	6,123	6,276	6,433	6,594	6,759	6,928	7,101	7,279	7,461	7,647
		Induced Cabot/Gateway Tractor-Trailer	0.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Total Tractor-trailer		10,629	10,895	11,167	11,446	11,732	12,026	12,326	12,634	12,950	13,274	13,606	13,946	14,295	14,652	15,018	15,394
	Design Peak Trip Vol	Autos		136	139	142	145	148	151	154	158	161	165	168	172	175	179	183	187
		Trucks		4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5
		PCU's	3	147	151	154	157	160	164	167	171	175	179	183	187	191	195	199	204
		Crossing Duration (ratio)	30.00%	74	75	77	79	80	82	84	86	87	89	91	93	95	97	100	102
Revenue Total		Total Rev		3,970,033	3,991,241	5,106,426	5,224,040	5,343,416	5,460,372	5,590,606	5,778,599	5,860,035	5,998,799	6,136,950	6,280,000	6,427,932	6,578,933	6,733,707	6,892,373
	Passenger Tolls			727,283	743,877	758,411	774,431	790,822	807,427	824,349	841,562	860,000	879,134	898,178	917,606	937,092	958,210	978,315	1,000,841
	Vehicle Tolls			1,528,873	1,516,650	1,385,162	1,414,300	1,444,321	1,475,007	1,506,066	1,538,567	1,571,754	1,605,640	1,640,303	1,676,014	1,712,331	1,750,024	1,788,590	1,827,000
	Freight Tolls			1,713,890	1,756,768	1,800,662	1,845,529	1,891,821	1,939,110	1,987,294	2,037,284	2,088,216	2,140,421	2,193,932	2,248,780	2,305,000	2,362,623	2,421,690	2,482,233
	Passenger Tolls	Incremental		34,080	34,740	35,352	35,844	[illegible]	36,326	37,016	39,141	40,932	42,299	43,832	45,404	47,014	48,665	50,726	52,080
	Vehicle Tolls	Incremental		207,030	211,032	215,090	219,241	223,470	227,793	232,201	236,703	241,295	245,982	250,760	255,649	260,634	265,722	270,916	276,217
Economic Total	Freight Tolls	Incremental		851,417	872,703	894,520	916,883	939,805	963,300	987,383	1,012,068	1,037,369	1,063,303	1,089,886	1,117,133	1,145,062	1,173,688	1,203,030	1,233,106
	Total	Incremental		1,108,837	1,135,050	1,164,160	1,189,971	1,218,449	1,247,431	1,277,063	1,308,112	1,339,666	1,371,384	1,404,484	1,438,180	1,472,710	1,508,075	1,544,303	1,581,413
Total Capital Investments (Outflow)	Pre-operation		0																
	Operations Phase		0																
	Infrastructure																		
		Civil Works	0																
		M & E	0																
		Systems	0																
		Rolling Stock	0																
	Sub total		0																
	Other (Design, Proj. Mgt)		0																
TOTAL CAPEX		$ 2004	0																
Present Values at Initial Discount Rate	Present Value Total Revenue over operation		23,077,000	764,210	760,339	679,021	641,459	603,119	581,137	552,164	529,323	503,787	477,113	454,280	432,407	411,672	391,963	373,178	355,352
	Present Value Capital Investment		0																
	Net Present Value		-163,688,900																
Benefit Cost Ratio and IRR	Benefit/Cost Ratio		0.12																

Indirect Transportation

				26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Marine Atlantic Impacts	Passenger Vehicles	Base Projection # Vehicle trips	2.50%	287,269	294,492	301,834	309,421	317,138	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Vehicle trips diverted	1%	-2,873	-2,943	-3,019	-3,094	-3,171	-3,251	-3,332	-3,415	-3,501	-3,588	-3,678	-3,770	-3,864	-3,961	-4,060	-4,161
		Net Vehicle trips		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Passenger Vehicle Revenue $	149	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Freight tractor-trailer	Base Projection Tractor-trailer	2.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Diverted Freight tractor-trailer	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Net Freight tractor-trailer		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Net Revenue $	237.28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Change in Pass. Car Equivalent Veh. (PCU)		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Total Operating Cost		111	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Wages	64.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Fuel	16.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Purchased Goods & Ser	29.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Subsidy Impact	- reduction subsidy from	41.8																
		Incremental gain (loss)		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Net Revenue	Operating Surplus(deficit)		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Capital Plan - Base	$ Millions																	
	Capital Plan - Down	$ Millions																	
	Total Cash - Base			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Total Cash - Down			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PV Base (2004)		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	PV Down		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Net Present Value	Base $ attributable to fixed link	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Apollo Impacts	Base	Total Volumes #	2.50%																
		Trucks # (est.)	12.00%																

Economic Methodology for Fixed Link Project

Phase 3 - Operation

26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41

SECTION 2 - Financial Analysis

Section 3 - Socio-Economic Impact

26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41

Economic Methodology for Fixed Link Project

				Phase 3 - Operation															
				26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
		Net Present Value	1,030,950	54,118	47,650	40,970	38,199	36,809	34,791	33,174	31,178	30,016	28,628	27,296	26,017	24,797	23,630	22,518	21,457
TOTAL OTHER IMPACTS		Net Present Value - Best	[illegible]	62,612	58,562	54,710	54,063	51,330	49,176	45,828	44,519	42,550	40,500	38,986	36,056	35,112	33,490	31,924	30,411
Social Impacts																			
	Employment	Construction & Operations																	
		NL - Skilled		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
		NL - Unskilled		15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
		[illegible]		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Total NL Direct Employment		40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
		Indirect Construction Employment	0.63	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
		Induced Construction Employment	0.5	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
		Total Annual FTE Employment		85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
		Tourism																	
		Total Incremental Spending		299,815	311,795	323,861	336,366	349,808	363,416	377,662	393,147	408,106	423,423	438,113	453,491	468,916	484,600	501,130	518,870
		Incremental FTE - Direct	12.0	6	7	7	7	7	7	7	8	8	8	8	8	9	9	9	9
		Incremental FTE - Indirect	0.24																
		Incremental FTE - Induced	0.13																
		Total Impact	10.3	9	9	10	10	10	10	11	11	11	11	12	12	12	12	13	13
		TOTAL RELATED EMPLOYMENT		94	94	95	95	95	95	96	96	96	96	97	97	97	97	98	98
	Wages	Construction & Operations																	
		Direct Payroll		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Indirect Construction Employment	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Induced Construction Employment	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Sub-Total Wages		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Tourism																	
		Incremental Direct Wages	23.0%	117,700	120,060	122,621	126,072	129,760	132,980	136,332	139,668	143,043	146,342	150,170	153,667	157,657	161,519	165,519	169,580
		Incremental Indirect Wages	33.0%																
		Incremental Induced Wages	13.0%																
		Sub-Total Wages	36.1%	180,120	184,337	189,097	193,743	198,210	204,000	208,340	213,126	218,701	224,166	229,683	235,340	241,136	247,073	253,161	259,390
		TOTAL RELATED WAGES		180,120	184,337	189,097	193,743	198,210	204,000	208,340	213,126	218,701	224,166	229,683	235,340	241,136	247,073	253,161	259,390
		NPV Wages	[illegible]	27,077	26,188	24,960	23,780	22,676	21,611	20,599	19,632	18,718	17,833	16,992	16,202	15,442	14,720	14,030	13,375
	Other Impacts																		

SENSITIVITY ANALYSIS RESULTS - BASE CASE

Variables

Base Case			
Debt Financing (Real)	8.0%	Annual to Peak Hour Design factor	
Long Term Inflation	2.5%	Safety Margin	1.25
Equity Real	11.0%	Auto - Peak duration - days	100
Equity Tax Rate	40.0%	Auto - Peak proportion of total	50.0%
Equity Pre Tax - Real	18.3%	Auto - Peak hours/day	6.0
Equity PreTax - Nominal	22.5%	Auto - Peak % of PADT	60.0%
		Auto Conv. Factor	0.063%
% debt financed	0.0%	Truck - Peak duration days	250
% equity financed	0.0%	Truck - Peak Proportion of total	85.0%
Nominal Grant $ Millions	$1,360	Truck - Peak hours/day	12.0
Blended Cost of Capital - Real	0.0%	Truck - Peak % of PADT	100.0%
Blended Cost of Capital - Nominal	0.0%	Truck - Conv. Factor	0.035%
Financing during Construction	5.0%	Auto Lab - Traditional Growth	1.50%
		Tourist Lab - Traditional Growth	3.50%
Social Discount Rate - Nominal	10.0%	Truck Lab - Traditional Growth	2.50%
Social Discount Rate - Real	7.5%	Auto Lab - Incremental Growth	0.00%
Grant Discount Rate	0.0%	Auto Tourist - Incremental GR.	1.25%
		Total Lab - Veh Growth	2.50%
Standard PY (FTE) hours	1850	Total Lab - % trucks	10.00%
		Truck Lab- Incremental Growth	1.00%
Marine Atlantic Productivity		Auto Lab - Surge	30.00%
Improvement factor		Truck Lab - Surge	0.00%
Wages	50.0%	Auto Cabot - Traditional Growth	2.50%
Fuel	10.0%	Truck Cabot - Traditional Growth	2.50%
Supplies	50.0%	Auto - Diversion from Cabot	10.00%
Weighted Average	43.9%	Truck - Diversion from Cabot	10.00%
		Auto exCabot- Incremental Growth	1.50%
Car Occupancy (in # of Adults)	2.67	Truck exCabot - Incremental Growth	1.00%
		Auto exCabot - Surge	30.00%
Construction Wages % of cost	30%	Truck exCabot - Surge	0.00%
		Total Vehicle trips - Cabot Trad	2.50%
Tolls		Cabot Rev/pass veh	148.00
Per auto	30.5	Cabot Rev/truck	257.25
Per other pass.	10		
Per tractor-trailer	161.25		

			Unit Toll % of Base Case Value			Traditional Market Growth Rate			Incremental Growth Rate			Diversion		
Results		Base Case	50.0%	150.0%	200.0%	1.0%	3.0%	5.0%	2.5%	5.0%	7.5%	0.0%	5.0%	15.0%
Operating Cash Flow	NPV	-647,922,996	-670,901,503	-624,944,489	-601,965,983	-656,004,538	-643,975,751	-625,263,591	-643,534,409	-634,655,348	-623,670,915	-676,970,747	-662,446,871	-633,399,121
	IRR	-9.53%	#DIV/0!	-6.60%	-4.84%	-13.27%	-8.49%	-5.42%	-8.56%	-6.93%	-5.37%	#DIV/0!	#DIV/0!	-7.48%
	Benefit/Cost	0.07	0.03	0.10	0.13	0.05	0.07	0.10	0.07	0.09	0.10	0.02	0.05	0.09
Direct	NPV	-559,155,170	-582,133,677	-536,176,664	-513,198,157	-557,989,554	-559,081,189	-561,416,181	-554,766,583	-545,887,522	-534,903,089	-537,737,132	-548,446,151	-569,864,190
Economic Impact	IRR	-5.28%	-6.66%	-4.11%	-3.09%	-5.27%	-5.25%	-5.30%	-4.98%	-4.33%	-3.51%	-4.06%	-4.64%	-5.98%
	Benefit/Cost	0.19	0.16	0.23	0.26	0.20	0.19	0.19	0.20	0.21	0.23	0.23	0.21	0.18
With Indirect	NPV	-333,459,458	-356,437,964	-310,480,951	-287,502,445	-332,725,835	-333,497,005	-335,276,521	-323,523,813	-296,780,053	-258,504,830	-365,516,918	-349,488,188	-317,430,728
and Induced	IRR	-1.42%	-2.53%	-0.44%	0.44%	-1.44%	-1.41%	-1.42%	-0.83%	0.63%	2.27%	-2.72%	-2.05%	-0.82%
Impacts	Benefit/Cost	0.52	0.49	0.55	0.59	0.52	0.52	0.52	0.53	0.57	0.63	0.47	0.50	0.54

			Capital Costs % of Base Case				Operating Costs % of Base Case		
Results		Original	-30%	-15%	15%	30%	50%	150%	200%
Operating Cash Flow	NPV	-647,922,996	-449,019,117	-548,471,057	-747,374,936	-846,826,875	-632,489,456	-663,356,536	-678,790,075
	IRR	-9.53%	-8.33%	-8.99%	-9.99%	-10.39%	-11.77%	-8.16%	-7.16%
	Benefit/Cost	0.07	0.09	0.08	0.06	0.05	0.07	0.06	0.06
Direct	NPV	-559,155,170	-360,251,291	-459,703,231	-658,607,110	-758,059,049	-543,721,631	-574,588,710	-590,022,250
Economic Impact	IRR	-5.28%	-4.15%	-4.77%	-5.71%	-6.08%	-5.76%	-4.84%	-4.42%
	Benefit/Cost	0.19	0.27	0.23	0.17	0.15	0.20	0.19	0.19
With Indirect	NPV	-333,459,458	-134,555,579	-234,007,518	-432,911,397	-532,363,337	-320,200,967	-346,717,949	-359,976,440
and induced	IRR	-1.42%	1.42%	-0.28%	-2.20%	-2.85%	-0.81%	-1.99%	-2.64%
Impacts	Benefit/Cost	0.52	0.73	0.61	0.45	0.40	0.53	0.51	0.50
Financing	Total Amt. To Finance	1,707,787,952	1,195,451,566	1,451,619,759	1,963,956,145	2,220,124,338	1,707,787,952	1,707,787,952	1,707,787,952
	Grant Amount	1,395,000,000	960,000,000	1,180,000,000	1,615,000,000	1,830,000,000	1,340,000,000	1,449,000,000	n/a
	IRR on project costs	8.0%	8.0%	8.4%	8.4%	8.0%	8.1%	3.0%	n/a

			Nominal Social Discount Rate				
Results		Original	4.0%	6.0%	8.0%	10.0%	12.0%
Operating Cash Flow	NPV	-647,922,996	-984,640,405	-858,432,186	-745,872,604	-647,922,996	-563,636,529
	IRR	-9.53%	-9.53%	-9.53%	-9.53%	-9.53%	-9.53%
	Benefit/Cost	0.07	0.17	0.12	0.09	0.07	0.05
Direct	NPV	-559,155,170	-829,396,451	-737,273,212	-643,553,095	-559,155,170	-486,404,183
Economic Impact	IRR	-5.28%	-5.28%	-5.28%	-5.28%	-5.28%	-5.28%
	Benefit/Cost	0.19	0.30	0.24	0.21	0.19	0.18
With Indirect	NPV	-333,459,458	-325,029,272	-367,116,721	-359,460,061	-333,459,458	-302,354,102
and Induced	IRR	-1.42%	-1.42%	-1.42%	-1.42%	-1.42%	-1.42%
Impacts	Benefit/Cost	0.52	0.72	0.62	0.56	0.52	0.49
Financing	Total Amt. To Finance	1,707,787,952					
	Grant Amount	1,395,000,000					
	IRR on project costs	8.0%					

			Interest During Construction			Inflation Rate			
Results		Original	2.5%	7.5%	10.0%	1.0%	2.0%	4.0%	5.5%
Operating Cash Flow	NPV	-647,922,996	-647,922,996	-647,922,996	-647,922,996	-583,509,141	-625,626,986	-720,033,612	-800,318,280
	IRR	-9.53%	-9.53%	-9.53%	-9.53%	-9.53%	-9.53%	-9.53%	-9.53%
	Benefit/Cost	0.07	0.07	0.07	0.07	0.05	0.06	0.08	0.10
Direct	NPV	-559,155,170	-559,155,170	-559,155,170	-559,155,170	-503,512,895	-539,874,591	-621,403,245	-689,624,191
Economic Impact	IRR	-5.28%	-5.28%	-5.28%	-5.28%	-5.28%	-5.28%	-5.28%	-5.28%
	Benefit/Cost	0.19	0.19	0.19	0.19	0.18	0.19	0.21	0.23
With Indirect	NPV	-333,459,458	-333,459,458	-333,459,458	-333,459,458	-310,234,162	-325,864,248	-353,961,865	-366,932,552
and Induced	IRR	-1.42%	-1.42%	-1.42%	-1.42%	-1.42%	-1.42%	-1.42%	-1.42%
Impacts	Benefit/Cost	0.52	0.52	0.52	0.52	0.50	0.51	0.55	0.59
Financing	Total Amt. To Finance	1,707,787,952	1,573,548,963	1,853,946,116	2,013,109,759	1,516,869,042	1,641,790,856	1,920,913,413	2,158,595,010
	Grant Amount	1,395,000,000	1,395,000,000	1,395,000,000	1,395,000,000	1,245,000,000	1,345,000,000	1,556,000,000	1,725,000,000
	IRR on project costs	8.0%	8.1%	7.9%	7.8%	7.8%	8.2%	8.0%	8.0%